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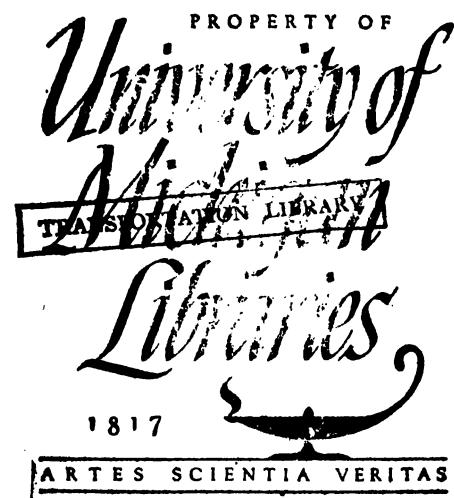


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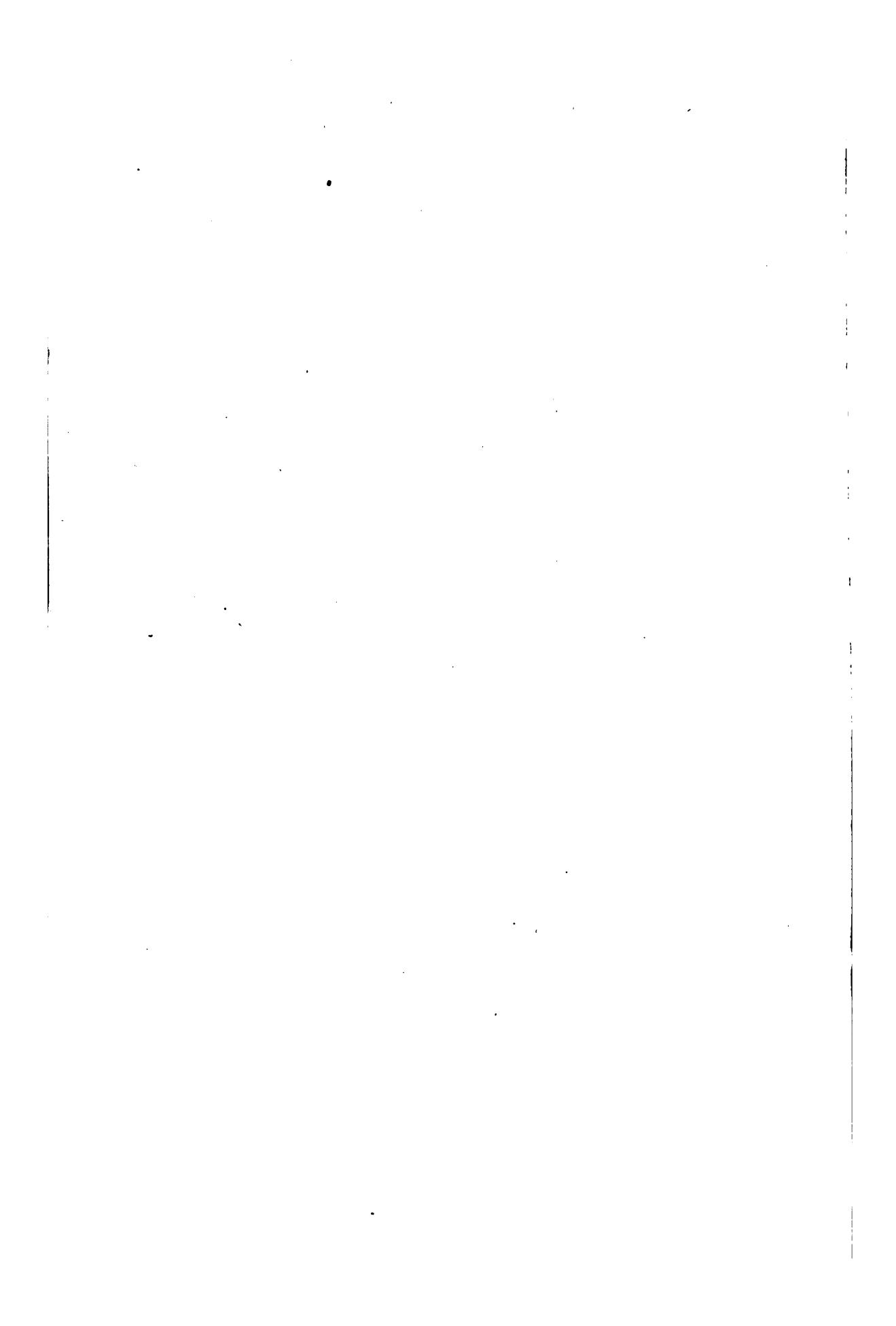
OF THE

PROVINCIAL INSTRUCTOR IN ROAD-MAKING
ONTARIO.

1898.







THIRD ANNUAL REPORT

OF THE

TRANSPORTATION LIBRARY

PROVINCIAL INSTRUCTOR IN ROAD-MAKING ONTARIO

1898.

(PUBLISHED BY THE ONTARIO DEPARTMENT OF AGRICULTURE.)

PRINTED BY ORDER OF
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THIRD ANNUAL REPORT

OF THE

PROVINCIAL INSTRUCTOR IN ROAD-MAKING,

1898.

To the Honorable JOHN DRYDEN,
Minister of Agriculture.

SIR.—I have herewith the honor to submit to you my third annual report, for the year 1898, on Road and Street Improvement in Ontario.

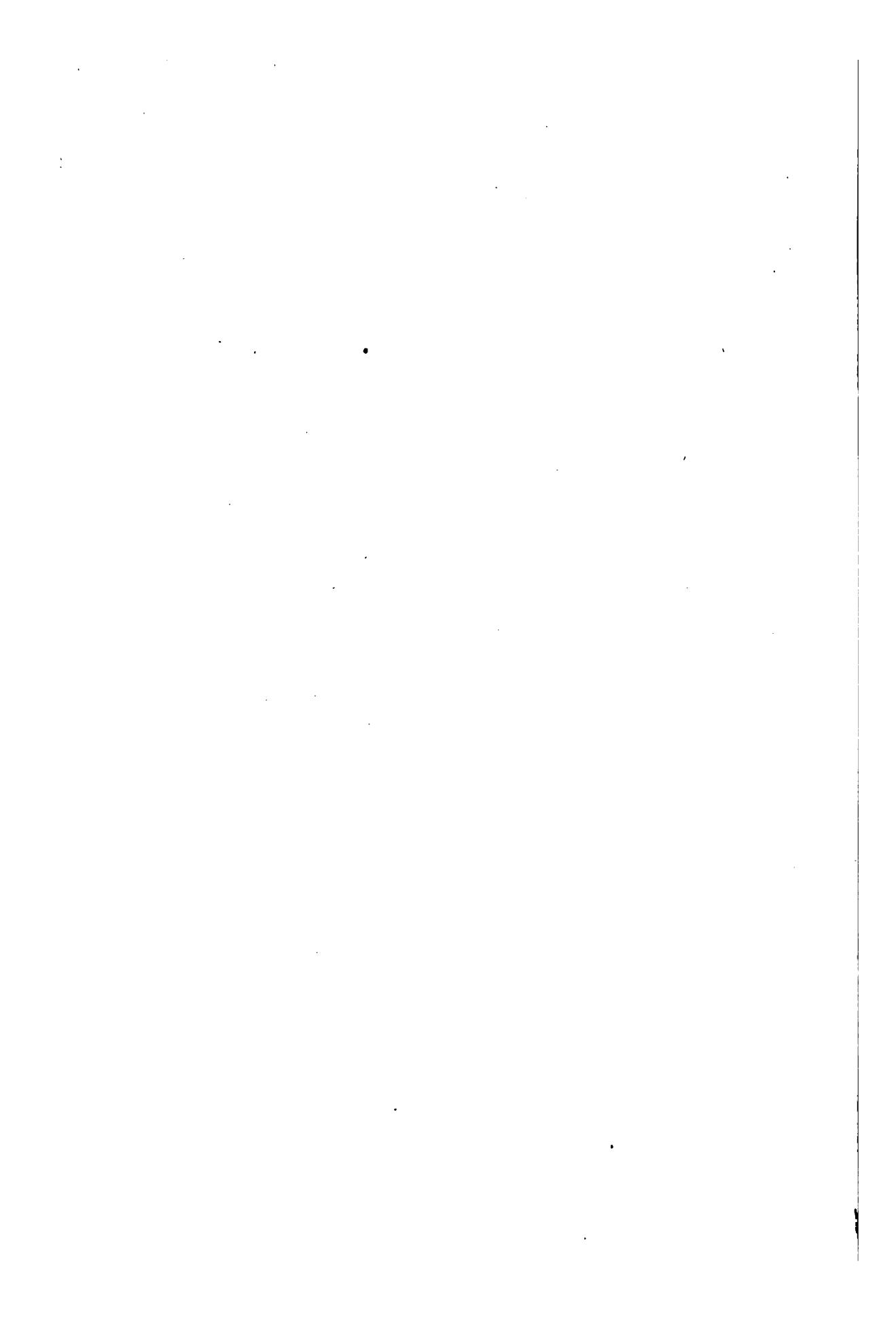
I have the honor to be,

Sir,

Your obedient servant,

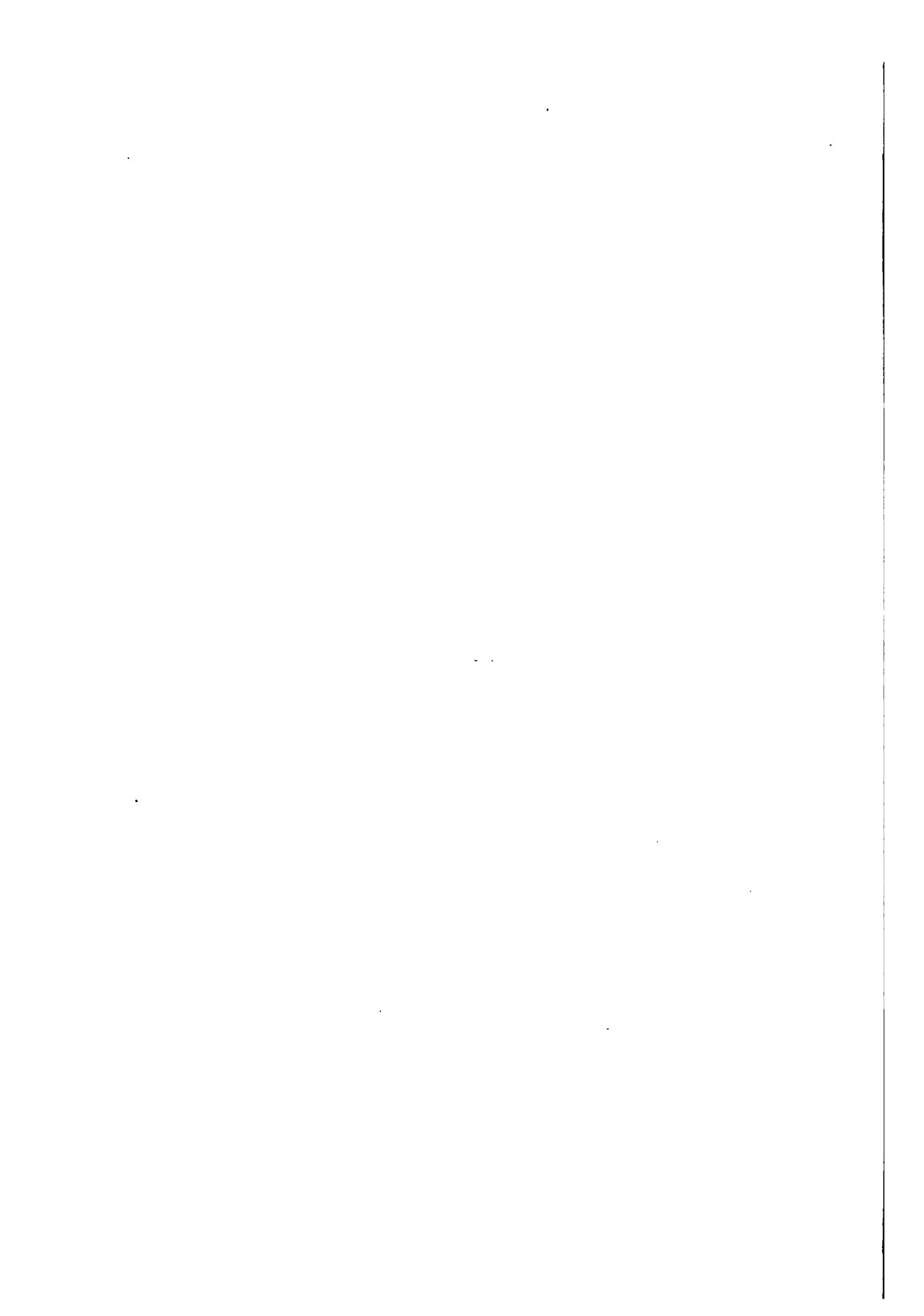
A. W. CAMPBELL,
Provincial Instructor in Road-making.

PARLIAMENT BUILDINGS, TORONTO,
ONTARIO, 20th March, 1899.



CONTENTS.

	PAGE.
Letter of Transmission	3
Transportation	7
Better Roads in Ontario	12
Road Reform	14
Should the Towns Assist ?	19
Petition of the Dufferin County Council	22
A Lesson from Scotland	23
A County System	24
Statute Labour	25
Road Reform in Outline	30
North Monaghan—Statute Labour abolished	31
Preparing for Roadwork	34
Directions for Pathmasters	35
The Best Use of Statute Labour	37
Gravel	37
The Essential Feature of Good Roads—Drainage	39
The Road Grader	42
Rock Crushers	44
"A Steam Roller an Absolute Necessity"	47
Weight of a Road Roller	51
Repairing with a Roller	52
Highway Culverts and Bridges :	
Location, Materials, Sewer Pipe, Cement-concrete Pipe, Arch Culverts of Stone and Concrete, Bridge Abutments, Design of Iron Bridges, Painting Iron Bridges, Painting Wooden Bridges, Economy of Iron Bridges	52
The Influence of Pavements on Public Health	61
Town Streets—Report to Windsor :	
Present Condition of Streets, Expenditure, Temporary Work, Frontage Tax, The Ward System, A Standard Pavement, Cedar Block, Asphalt and Brick, Cost of Pavements, Classification of Streets, Construction of Broken Stone Road- ways, Rolling, Curbing, Drainage, Main Entrances to the City, Sidewalks, Recommendations	66
Specifications for Cement-Concrete Walks	77





THIRD ANNUAL REPORT OF THE PROVINCIAL INSTRUCTOR IN ROAD-MAKING.

TRANSPORTATION.

The question of transportation is every year assuming a greater prominence, a deeper meaning to the people of Canada. Every year is turning greater activity renewed energy towards the improvement and extension of canals and railways, harbors, and all facilities for carriage and traffic associated with them. The inauguration of a domestic and foreign penny postage, which marked the beginning of the present year, was but another expression of the desire for free and uninterrupted communication, not only within the country but with other nations as well; so also the introduction of the telephone and telegraph of comparatively recent years. Lands excepted, the value to man of most material things is created, in part at least, by transferring them from their original position to another. Transportation is one of the most important problems occupying the minds of engineers to-day, and no field offers more reliable and remunerative opportunities for investment.

The national life of Canada is but in its infancy, and we have a country of magnificent distances and resources. The feeling that our means of communication cannot be too numerous is steadily on the increase, and the leading minds of the country have taken this view of the situation. New railways are needed, and new canals are needed to develop areas not yet reached, to provide less expensive, more capacious and more rapid transportation, to regulate rates, and to stimulate invention and enterprise towards securing cheaper methods and means of carriage.

Public opinion has moved rapidly and energetically along the policy of improving the larger means of transportation, ocean carriage, canals, railways; on the other hand the arteries and veins leading to and from these, and which are of such vital importance to the Ontario farmer and through him to the country as a whole, have been sadly overlooked, with the result that a bushel of wheat belonging to the Manitoba farmer can be carried by boat to Montreal or New York, a distance of over 1,200 miles, and handled at each terminus for about four cents; or only twice the amount it costs the Ontario farmer to deliver his wheat at the nearest market over the country road.

That there is an important relation between the common highway and the greater avenues of trade is plainly apparent; an importance which is greatly intensified by its bearing upon agriculture, and the value of agricultural prosperity to the Province. Fruit culture, the dairy, grain production, every department of farm enterprise is intimately associated with and dependent upon transportation, though in varied matters of detail.

Wheat, to which reference has been made, is but an example. The great waterways extending from the head of Lake Superior to the Atlantic Ocean the Canadian Pacific Railway extending across the continent, have brought into competition with the farmers of Ontario the wide grain-producing areas of the North-West. The wheat of Central Russia has easy access to the markets of the world by means of the Volga; Hungary possesses the Danube as a cheap water route; the Argentine Republic is served by the Rio de la Platte and the Parana, whereby ocean vessels may ascend a distance of 500 miles in the interior of the country. Africa with its great water routes from the interior of the continent to the seaboard, with its railways now under rapid construction, will no doubt soon enter into active production from its almost illimitable wheat areas. The surplus from these countries reaches the markets of the world by systems of transportation, the cost of which is being steadily lessened, and the result upon the agriculture of Ontario, the basis of our wealth, must be very marked indeed.

The farmer pays the cost of transportation. When the price of wheat at Fort William is one dollar a bushel, the farmer living at that place receives that amount for the grain he delivers at the elevator. On the other hand the farmer delivering his wheat at Edmonton receives one dollar less the cost of carriage and handling between Edmonton and Fort William. In the same way an English farmer who can haul his wheat to the market in London when wheat there is at \$1.12 per bushel receives that amount for his grain; while on the other hand the Ontario farmer receives that amount less the cost of transportation and hauling between Ontario and London. The farmer of Argentina who raises his wheat as cheaply as the Ontario farmer and who delivers his wheat to the ocean vessel on the River Parana, has a cheaper means of transportation than has the Ontario farmer who has to pay for an expensive carriage by railway before reaching the seaboard.

The cost of labor and production is more nearly approximating the world over year by year; the value of the surplus supplied to the markets of the world is fixed by the lowest price accepted, not the highest or intermediate amount; the home market is governed largely by the foreign market. The profit, therefore, which the Ontario farmer can derive from his produce depends to a very great extent upon a decrease in the cost of transportation. There is frequent complaint that the rates of railway and water communication are high, that they absorb too great a proportion of the farmer's profits. Nevertheless these rates are to-day much less than they were a quarter of a century ago—much less probably than could have been anticipated. And while the rate of railway and steamboat transportation is regarded as high, we are met with the very striking comparison that one ton can be carried by water for a thousand miles or more, and two hundred and fifty miles by rail, for the cost of moving one ton only five miles over the common roads.

While this great change and improvement has been affected with regard to rail and water carriage, the case has remained practically the same with regard to travel over the common roads. Ontario has 65,000 miles of country roads, and slightly over 6,500 miles of railway. With commendable enterprise, an immense amount of capital, both public and private, has been invested in the latter, with profit to the country and to the stockholder. It will scarcely be pretended, invaluable as the railways are, that they are of more importance to the country than is the primary system of transportation, the common highway. Yet so important have the railways been considered that had an equal amount been spent on the common roads these latter would have been built at an average cost of \$3,000 per mile, obviously an expenditure which, judiciously applied to the roads in accordance with the requirements of traffic, would have made this Province one of the best paved countries in the world.

In minor ways the more local means of transportation are being facilitated. Bicycles are becoming more universally adopted as a convenient means of travel. Electric railways are radiating more and more from the centres of population. The automobile carriage has made progress during the year. They are to be counted by the hundreds in London, England; and by the thousands in Paris, France. Their manufacture has been vigorously started in Ontario, and a dozen or more are in use in Toronto, while their number is rapidly increasing. Although scarcely past the experimental stage, their great utility has been demonstrated. A brief period promises a more nearly perfected vehicle at a price much reduced from that for which they are now offered. When their use has more fully developed, they are likely to exercise a considerable influence upon the public roads, by creating a much greater demand for road improvement from the people of the towns. Present indications are that they will provide a cheap and convenient means of travel and transport, not merely within the towns, but over the country roads as well.

A most erroneous view has been taken by a few, of the influence of electric radial railways upon the use of the common highway, the belief being advanced that they would eventually lessen the importance of the common road. On the contrary, the electric road is more likely, by increasing the suburban and rural population, to increase the need of good roads. The roads are the feeders of the railroads and canal, and will retain the same relation to electric roads. Electric roads will no more do away with the necessity for the best common roads, than have railways done away with the necessity for deepening and widening our canals. All our means of communication and transportation are needed, all are more certain to increase rather than to decrease in importance. The presence of electric roads in a district will increase population, increase travel, increase the use of the common road ; and, inversely, the improvement of the common road will increase the use of the electric road, acting as a feeder to it.

All our modes of travel, all means of conveyance have a decided tendency to remain, merely adjusting themselves to circumstances. Over the common road must first pass all the freight received by the railways, steam and electric ; over the common road must pass all the freight delivered by the railways. The horse, in spite of other means of conveyance, must remain for use in farming operations, and as such must remain for use on the common roads to compete with and regulate the cost of transportation in a manner similar to the action of railways and canals upon one another.

That our roads are bad is due to various causes, some of which could have been avoided, while others could not. Chief among these latter, the unavoidable causes, are the sparseness of population whereby a long road mileage is necessary to serve a few farms ; and the character of our climate, which, with great extremes of heat, frost and moisture, is not favorable to the easy maintenance of roads. Causes which could have been avoided are the unsatisfactory systems of road construction and control which, satisfactory at one time, have outlived their usefulness; the invariable tendency in a new country is towards work of a temporary kind to answer immediate wants without a view to permanency ; and the fact that the great majority of the people of this country, not having travelled in European countries, have no conception of what they should achieve and demand in the way of good roads.

A most unfortunate lethargy has existed throughout Canada as to the need for better farm roads. The farmer has said : " We have horses which are often in idleness, we ourselves have plenty of time, and we can therefore afford to drive slowly through mud, carry small loads, be entirely shut in at times by impassable roads, cut off even from the post office, the market, the school, the church, the neighbor, rather than pay money, of which we have little, for better roads." The townsman has said : " If the farmer wishes to travel in the mud, live in isolation ,

reach the town only once a month, he can do so. It is none of my concern. I he comes but seldom, when he does come he must buy more of my merchandise, that is all."

All this is radically wrong. It is mutually important to farmer and townsman that the country roads should be of the best, that traffic and intercommunication of all kinds should be brisk. Free and uninterrupted intercourse for the farmer in his commercial and social relations will advance the intelligence of the farming community, will create for the farmer more ways of money-making. The greater prosperity and refinement brings in their train greater needs, together with the means of obtaining them. Along the highways will flow wealth and culture, to be participated in by the villages, towns and cities which directly or indirectly, through the retail or wholesale merchants, are mainly dependent for support upon the agriculture of the Province.

The value of agricultural land is shown by experience to be in direct ratio to the condition of the roads by which it is reached. With no roads leading to it, land has no value. When the first wagon track is made, land first obtains a real worth. In proportion to the improvements made to the wagon track, the value of the land advances, and only when property possesses the best means of communication over first-class roads does it attain its greatest worth.

Distance is measured by time and ease of travel, not by miles. Land situated one mile from the market town, but with a boggy road intervening, is frequently of less value than an equally fertile property ten miles from the market, but having good roads communicating with it. A ten mile drive over a good road is easily less disagreeable than a drive of one mile over an excessively bad road. A wagon load of produce can frequently be drawn to market over ten miles of good road; while one mile of swampy, bad road, can render the moving of marketable produce an impossibility.



BETTER ROADS IN ONTARIO.

Road and street improvement has continued to be actively urged and discussed throughout Ontario during the year 1898 with most beneficial results. The procedure outlined in the first annual report of this department has not been materially altered. Public meetings have been held in all quarters of the Province, written reports made in a considerable number of instances, and literature distributed.

The most noticeable effect of educational influences has been, perhaps, a lessening to a remarkable degree of the prejudice and suspicion with which the movement was at first met, particularly in the agricultural sections. The desultory manner in which road improvement had been urged prior to the appointment of a Provincial Instructor in Road-making had done much to create a misapprehension with regard to the object of the reform. There was a feeling that the sole aim was the abolition of statute labor. There was an apprehension that in place of this, a burdensome system of taxation was proposed, and that the townships would be bonded for the purpose of constructing the roads in an expensive manner.

It is gratifying to record the very different feeling with which the problem is now met throughout the Province. There has been every success in drawing the attention of the people to the great benefit of good roads, and this has resulted in a desire to adopt the most approved methods for improving them, both as regards actual construction, and the system of control.

There has been some misconception with regard to the class of roads advocated for this Province. "Good Roads" so readily suggests the highest type of road found in England and other European countries, that many have at once concluded that similar roads were contemplated for this country. The proposition, viewed from this standpoint, naturally invited antagonism, as the expense consequent upon so radical a change would necessarily entail burdensome taxation.

"Better Roads" rather than "Good Roads" is perhaps more expressive of the true meaning of the present agitation for reform. The roads of to-day have reached their present state by a process of evolution and development, and it is only by a similar process for the future that the desired end can be reached in an economical manner. The difficulty, however, has arisen from the fact that the methods, up to within the last couple of years, have been nearly identical with those pursued by the pioneer settlers of the country a century ago. The same system, statute labor, has been almost universally employed and the same imperfect and erroneous ideas with regard to actual construction have prevailed. It is in the correction of these that the greatest hope for the future lies.

"Better Roads" are everywhere being built in the rural districts. This is to be seen largely in the drainage which heretofore has been so much neglected. A large amount in the aggregate has been spent on modern road machinery, chiefly graders and stone crushers, whereby a much greater extent of improvement has been made. In addition to better drainage and grading and the purchase of machinery, councils are appreciating the need of procuring better gravel and stone, more durable culverts, and are in many different ways evincing their greater interest in improving the roads.

All the cities of Ontario, nearly all of the towns and many of the villages, now use artificial stone (cement-concrete) sidewalks. In some of the smaller towns, such as Ingersoll, Tilsonburg, Aylmer, Ridgetown, nearly all the sidewalks have been relaid with this material, and most of it has been down for five or six years. Collingwood, Owen Sound, Kincardine, Walkerton, Listowel, Mt. Forest, Fergus, Guelph, Barrie, Stratford, St. Mary's, Woodstock, Strathroy, Chatham, Norwich, Galt, Berlin, St. Catharines, St. Thomas, Niagara Falls, Drummondville, Brockville, Cornwall, Kemptville, and others, have all laid large quantities during the past year.

As much interest is being taken in the proper construction of streets as of sidewalks, and where once the municipality provides a proper equipment of machinery and commences to work on right lines, the same progress will be made as in sidewalks. Within the last few years, Chatham, St. Catharines, St. Thomas, Stratford, Galt, Berlin, Woodstock, Brantford, Ingersoll, Niagara Falls, Barrie have all supplied themselves with complete outfits of road-making machinery, including rock crusher and steam roller, and are doing excellent work.

It is needless to say that the larger cities, Toronto, London, Ottawa, Kingston and Hamilton also possess these implements for the construction of macadam roads. In addition reference may be made to Peterborough, Brampton, Renfrew, Brantford, and Cornwall, where equally advanced steps are being taken. In Cornwall a by-law to raise \$35,000 to be spent this year for road machinery and street improvement, was submitted to popular vote and passed. The spirit in which this work is advancing may be instanced by the following communication from G. H. Ferguson, a member of the council of Kemptville:

KEMPTVILLE, Ont. Sept. 27, 1898.

A. W. CAMPBELL, Esq., Prov. Instructor in Road-Making,
TORONTO, Ont. Can.

DEAR SIR,—Your letter of the 16th inst. I duly received. As you will perhaps remember we had about \$6,000 to spend on street improvement this year, the balance of our loan being to take up outstanding debentures. We have built about 20,000 square feet of granolithic sidewalk at a cost of twelve and one half cents per square foot. We also invested in a champion rock crusher and roller at a cost of \$1,000. We have built some macadam road much on the prin-

ciple laid down by you, and apparently it is an excellent piece of work. Of course time will tell what the quality is. The balance of our funds we propose expending also in macadam roads. The sample we put down here in the village has had the effect of starting an agitation in the surrounding municipalities on the good roads question, which no doubt will bear fruit in the near future.

Yours truly,

(Sgd.) G. H. FERGUSON.

ROAD REFORM

The road reform movement has, in Ontario, passed through a number of interesting stages. In spite of the fact that the first organizers were, in the main, farmers, business, and professional men, and journalists, it was first attacked on the score of being a fad of the bicyclists. A little later as the bicycle became more and more generally recognized, not as the toy of a sportsman, but as a vehicle of practical utility even among farmers, this ground became untenable. The opposition then settled into a defence of statute labor in its entirety, while road reform was described as an effort to impose a burdensome tax upon the farmer for the construction of expensively built stone roads. All this has gone by, and we find councils and people accepting more and more the principles of the movement, and everywhere efforts are being put forth to carry them into practical execution. There is everywhere a reasonable desire to give statute labor due credit for the great amount of good it has done; to accept it still where the local circumstances make it advisable as a means of securing better roads; but where the condition of the people has so advanced, that statute labor is no longer a just, equitable and serviceable system of taxation, it should be abolished as any other unjust tax. That is the feeling which is rapidly developing throughout Ontario to-day, one which because of its reasonableness, it is useless to oppose or curb—we can only mould and direct it.

A century has gone by since the passing of the first statute labor law in Ontario. It was an Act of the first parliament of Upper Canada, convened by Lord Simcoe, the first Lieutenant-Governor, at Newark now Niagara-on-the-Lake. This was in 1796. Less than ten years later England and Scotland repealed their statute labor law because of the excessively bad condition of the roads, substituting a system of better management and expenditure which under, the methods of Macadam, Telford and McNeil, have amply justified the change. Ontario still retains the system of statute labor, and has learned few of the actual principles of road building from the men who worked so great a change in the roads of the Motherland.

The improvements made to the roads of Ontario are by no means all due wholly to statute labor. As a part of the first settlement duties, road allowances

were cleared of trees, and of stumps sufficiently to form a wagon track. Through the Huron Tract, the Canada Company spent large sums in opening up roads. The Governor's Road, from London to Toronto, the Kingston Road along Lake Ontario from Toronto to Kingston, the old stage road from Kingston to Montreal; the London and Hamilton Gravel road; the Sunnidale Road; the Hurontario Road, Yonge Street, the road from Hamilton to Niagara; these and many other roads in different parts of the Province are examples of the effect which Government aid, toll road companies, and individual efforts apart from statute labor, have had on the roads. In addition to this have been large annual expenditures of money by county and township councils.

Statute labor will do a certain amount toward the making of roads. In the brave pioneer days of this country, it did much toward taking out stumps, grading, corduroying; and has since done considerable toward gravelling or covering with broken stone in certain sections. But past a certain point statute labor will not improve the roads. When the roads have reached this point a backward trend is distinctly noticeable. They commence to deteriorate rather than improve. The incentive which actuates the pioneer who feels, desperately almost, the need of better communication with the market, the mill, his neighbor, has been lost. At this point statute labor commences to be performed in a perfunctory, shiftless, idle manner, becomes the farce that is rapidly condemning the system in all the older sections of the Province.

It is at this juncture that we turn to other countries for information as to the best course to pursue. In none of them do we find a system wholly applicable to Ontario, but our policy in this as in other matters in which we hope to progress should be to adopt that which is suitable to our conditions and surroundings, discarding that which is unsuitable.

A review of the systems used in countries which afford us a model for road construction indicates to us one great defect in our present methods. This is the inefficiency of oversight. In this respect our statute labor has become, not a system, so much as an entire absence of system. With any system rightly so called, there must be centralized control, directly responsible to the people. In France certain of the roads are maintained by the Government of the republic as national roads. The charge of these roads is deputed by the Government to the Chief Engineer who in turn allots different departments to the different members of his staff. Other roads are managed very much as county roads; others, of least importance, would correspond much to our township roads. In all these there is the one general principal—that of centralized control. On the roads of least importance the ratepayers may, if they so desire, work out their special road tax; but this work is done under the direction of a competent supervisor in whose charge the care of the roads is placed, and who is directly responsible for their condition and for the proper outlay of money and labor upon them.

In England, national roads do not exist, but in the county roads and parish roads, the principle of centralized control again is displayed. So it also is in Germany.

In Massachusetts, on this continent, we find the best models of road construction, built by the state. They are built and maintained by centralized authority; large sums are being expended by the state, and it is expected that ultimately one-tenth of the road mileage will be built in this way. This system it is expected, will serve two purposes. One is the construction, in a permanent and durable manner, of the leading highways of the State; the other that of educating the people of the State as to the necessity of having good roads and as to the best manner of building them, so that the roads of lesser importance, still under the control of township councils, will be built in a durable and economical manner.

As has been emphasized in a preceding paragraph, the lesson to be learned from such examples as this, is not that we should adopt the system of France or England, or Germany or Massachusetts—but that we should adopt the principle of centralized control.

It is useless to say that we need not look to more experienced countries for models, by asserting that we cannot afford to build such roads as France, England, Germany and Massachusetts possess. There is no part of the Ontario Good Roads movement which advocates for this Province such expensive stone roads. But, we, if our resources are less, must husband them more carefully, apply them more judiciously and skilfully—and for this we must seek the advice of older and more experienced countries. If the various municipalities are spending as much as they consistently can on their highways, then the only means of improving the roads is to improve the methods of building and maintaining them.

There is no desire on the part of the road reformer to adopt revolutionary plans. It is rather by a process of development and growth that reform should be accomplished. How then, to apply the principle of centralized control to our present system is the first part of the problem to present itself. The trend of thought as we find it in many parts of Ontario affords a solution. County councils are taking over leading roads to build and maintain and over these competent supervisors and foremen are being placed. The feeling adverse to statute labor is rapidly increasing, township councils will find it necessary to abolish it, and over the township roads will be placed competent foremen and supervisors. However radical the ultimate outcome may seem to those who still have faith in statute labor, the process of reaching it will be one of development and growth, a gradual change. Where the system is retained, statute labor will be less and less faithfully performed, the annual appropriations of township councils will be compelled to increase, and statute labor will shrink to less and less until extinct. It is merely

a process of evolution—an instance of the survival of the fittest. It vanished from England and Scotland nearly a century ago. In the older portions of Ontario it is slowly but surely passing away.

Taxes always have been, probably always will be unpopular. One cause for this is that the reason for taxation is not asked; money paid in taxes is considered a direct loss, almost highway robbery, from which no return is received. The real spirit of a tax, however, is a united effort of citizens in obtaining some common necessity. Take for example, the money spent on roads. What would be the result if this tax were utterly abolished, no work done on the roads, no roads provided, and each man left to build a road to the market-town for himself alone? The supposition is so impracticable that it is absurd. Under such circumstances we would quickly find farmers clubbing together their money and work as they found themselves mutually interested, until we would have practically a township corporation again formed and a tax established. It is the same with schools, the same with the administration of justice, the construction of drains, etc. Taxes are a measure of economy, not extravagance. They are an unalterable example of the old adage—"in union is strength." While the principle of taxation thus commented on may seem to many too simple for consideration, it is an axiom few stop to consider, it is frequently lost sight of, and taxation becomes unreasonably unpopular.

It is this unreasonable unpopularity that so frequently lends strength to the question "What will good roads cost us?" Does the same man refuse to build fences, a stable, a house, because of the cost? What would it cost him if he did not fence his farm? What would it cost if he allowed his horses and cattle to remain unprotected all winter instead of providing warm stabling? What would it cost if he lived in a log cabin instead of a comfortable house? What are bad roads costing him?

When we commence to consider what bad roads are really costing us, the sum of it all becomes very difficult to comprehend. The cost of good roads can be stated in dollars and cents, but it is not so with bad roads. Bad roads are costing some citizens of Ontario half their lifetime in driving over them; to drive one mile occupies the time that it would take to drive five if the roads were good. They are costing many a farmer much of the self respect he feels when driving along a good road at a good pace with clean buggy, clean harness and clean horse. They are costing our farmers small sums which soon aggregate large sums, in repairs to wagons, buggies, harness and whips. They are costing the privilege of attending church and public meetings at many seasons of the year. They are costing the young people of the farms a considerable part of their education; costing them the privileges of society which every healthy mind demands. They are costing the rural districts a large share of their population which, in disgust at the stagnancy of farm life, drifts to the city, overflowing the profes-

sions and trades, and lessening the value of farm property. This and much more is the cost of bad roads. To doubt that the loss is much more is to forget the loss incurred by the business aspect of farming, by trade and commerce, by the railway and transportation system, by the manufacturing and dairying industries, all of which are both direct and indirect losers.

If then we centralize control by placing properly qualified supervision over our roads ; and if, in providing proper means to carry out the work under this supervision it is found necessary to substitute for the cumbersome statute labor, a special road tax, what are some of the plain, practical improvements which would be made on the roads ? A plain, practical question, requiring, however, a volume to fully answer.

Carried out as it should be, and would be, for the citizens would demand it, the road machinery would be handled to better effect, work would be done at the most suitable season of the year or whenever repairs were demanded ; improvements would be made by men accustomed to road-work and therefore skilled ; materials for roads, gravel, timber, etc., could be chosen and prepared under one man to better advantage than as now ; the work would be done with a view to permanency, and the principles of roadmaking more closely followed.

The first principle applicable to all the roads in this Province, is good drainage. "Take the water out and keep the water out" is a rule which must be followed in the making of every road. It is not enough to dig trenches at the side of the road and call them drains. These trenches must be real drains ; that is they must have a good fall to a clear outlet, and be in every respect capable of carrying the water away. The road must be rounded up in the centre so as to shed the water quickly to the side drains. There must be a track in the centre of the road along which travel can pass. This track must be hard and smooth so as to afford the least friction to travel, prevent ruts and at the same time permit water to run off the sides quickly. Ruts and holes must not be permitted to form but must be filled up as soon as they appear. The drainage must not be abandoned with taking care of the surface water, but in many instances must extend below the surface in the form of tile underdrains, so as to maintain a firm foundation and lessen the destructive action of frost—injurious only to wet and water soaked roads. In addition to the simple work on roads, better methods with regard to bridge and culvert construction are greatly needed. The principles above enumerated with respect to roads require an infinity of special methods and treatments in arriving at the best results according as the land is high lying or low ; is clay, sand, vegetable-mould, etc.; is difficult or easy of drainage; according to the extent of travel, the quality of road metal obtainable—these and many other varying conditions. That roadmaking and highway work of all kinds is considered a matter in which every man is proficient, is probably one of the evils underlying the bad condition of our roads to-day.

In the application of a few simple, fundamental principles lies the skill required in roadmaking as in other arts and sciences which are regarded as difficult. Roadmaking is an art, requiring much experience and skill.

Good roads bring prosperity, and prosperity brings good roads; they go hand in hand, each assisting the other. A recent writer has said that Spain would not have lost Cuba if she had joined the good roads movement. Far-fetched as the assertion may seem, it contains the element of truth. In spite of a long Spanish sovereignty, the common highways of Cuba, most fertile island of the Atlantic, are still of the most wretched description. Barbaric Spain has not yet learned what Rome knew one thousand years ago, what England well knows to-day, that roads are the arteries of commerce along which flows the life stream of a nation, bearing success, civilization and contentment to the inhabitants. The value of good roads to a community, as to a nation, cannot be overestimated.

SHOULD THE TOWNS ASSIST ?

A difficulty in the way of obtaining better roads in Ontario, is that, under the present system of township management, the entire cost of road building falls upon the farmers. The people of the villages, towns and cities, to whom country roads are as necessary as to the farmers, and who compose nearly one-half of the population, pay nothing towards their construction or maintenance.

While it is necessary that the farmer should have roads to haul his produce to the centres of population, he also uses the roads to draw back to the farm the supplies purchased in the towns. It merely happens, as a matter of convenience easily understood, that the farmer draws his produce to the town and his purchases back to the farm instead of the merchant hauling his merchandise to the farmer, and the produce of the farm back to the town.

It is only a century or so ago since the active settlement of Ontario commenced. It was at that time the statute labor system was established. In addition to this, the Provincial Government spent the greater part of its revenue on the construction of roads and bridges. Since that time the distribution of the population has materially changed; the statute labor system remains for the construction of country roads, applying only to the rural districts, while the provincial aid has been withdrawn, thus wholly relieving the people of the towns and cities from their share in the cost of road building.

The change of conditions has taken place so gradually that the evident disparity resulting has remained unnoticed. The system of road control and taxation has not grown and developed with the growth and development of the country. The result, so far as road control is concerned, is similar to a full grown man still wearing the clothes in which he went to school.

There does not appear to be any reason why the farmer and rural population should pay the entire cost of road building, any more than they should meet the entire cost of railway and canal construction. A system of good country roads is an expensive public work, in every way necessary for the development of a country, and so long as the farmer bears the entire burden, it is manifest that the desired end, good roads, will be difficult if not impossible to reach. In any event, the attempt to do so comprises an injustice.

The towns are asking for good country roads. They are beginning to realize how important for them it is to have free and uninterrupted communication with the surrounding country districts at all seasons of the year, and would no doubt be willing to pay a fair proportion of the cost in order that road improvement would progress more rapidly. This very interest which is being displayed, is the strongest evidence as to the mutual right of townsman and farmer to pay for the construction of a country road system.

The principle, since the inauguration of the good roads movement on this continent, has been recognized in a number of American states, such as Massachusetts, Connecticut, New Jersey, Rhode Island, Vermont and New York, by the establishment of systems of state aid, whereby the state funds, derived from the entire population, urban as well as rural, contribute to the cost of country road building. In all European countries national aid in one form or another is given, thus taxing the city and town population.

In England the county council has entire jurisdiction over the roads, and is aided by a grant from the national treasury. A county engineer is appointed, a salaried officer, whose sole duty is the supervision of road work. The county is divided into districts, and the detail of the road work is attended to by assistant engineers acting under the parishes. The money required for the maintenance of highways is obtained by a precept issued by the county council to the various parish councils demanding the amount expended on the roads of the parish. This amount is collected in the general parish (or township) taxes, levied on the assessment values of property. A system of county management has been extended to all parts of Scotland. The roads of Ireland are under a county engineer and several assistants, each of the latter having his own district, improvements being regulated by a grand jury presentment system.

French roads are national, departmental and communal; corresponding largely to state, county and township roads. The national roads radiate from Paris, extending to all the important cities and departments, and are under a special engineering department (department of bridges and roads) attached to the national government. The second and third classes, departmental and provincial roads, are in a general way under local authorities, but departmental roads are usually entrusted to the care of the national corps of engineers.

Germany has a magnificent system of turnpikes built and maintained by the national government. They are under the general management of a state road commissioner, while he is assisted by an extensive staff of road directors and inspectors. Other roads are known as "country roads," and are built and maintained by the several parishes through which they pass.

The highways of Austria are classified as state or Imperial roads, provincial roads, district roads, and community roads, according to the authority constructing and managing them. The cost of building and maintaining the Imperial roads is derived from the national funds, the cost of provincial roads from the provincial funds, district roads from district funds. A little of the cost of community roads is borne by the several communities interested, aided in certain cases from the district funds. For the Imperial and provincial roads the best of engineering skill is employed, while for immediate repairs, road keepers are at work constantly.

Italian roads are under the supervision of the Minister of Public Works, and are national, provincial, communal, or vicinal, according to the source from which taxes for construction and maintenance are derived.

The more important roads of Denmark are controlled by the county councils but are subject to the annual inspection of a state engineer; the roads of lesser importance are governed by the parish or township councils.

The main roads of Belgium, those routes running from one part of the kingdom to another are controlled and managed by the state; another class, provincial roads, are controlled by the province; a third class, communal roads, are controlled by the communal authorities. The construction of these roads is entrusted to a corps of engineers.

In the Netherlands, a network of roads, providing convenient travel from one part of the country to another, is maintained by the general Government; other roads are at the expense of the various provinces and communities benefited.

The federal government of Switzerland controls a few of the important roads, but in the main they are built and maintained by the cantonal government through whose territory they pass. The construction and repair of roads of lesser importance pertains to the several townships through which they pass.

Spain, decayed and tottering, the vestiges of an ancient magnificence falling from her, has not joined the good roads movement; nor has Turkey, the home of barbarism. Russia, too, has been exceedingly backward in road-building, and as a result her extensive and rich dominions are still practically undeveloped.

The immense benefit conferred by good roads has practical illustration in many parts of Europe, where it is of unusual occurrence to see a load drawn by more than one horse. In these countries so excellent are the roads, that anyone owning a team of horses does not consider himself dependent upon the rail-

roads for transportation, as wagon loads of from three to six tons are frequently drawn several hundred miles in competition with railway rates. In these cases the roads are, of course, of the best possible construction, built and maintained under experienced engineering supervision, and are a skilful compromise between ease of grade and directness of route.

PETITION OF THE DUFFERIN COUNTY COUNCIL.

The following petition is intimately associated with the principle just discussed, state aid, and was presented to the Legislative Assembly of Ontario by the County Council of Dufferin.

To His Honor the Lieutenant-Governor in Council, and to the Members of the Legislative Assembly of the Province of Ontario :—

The petition of the Council of the County of Dufferin humbly sheweth :—

That an averaged organized and settled township of the Province of Ontario expends annually about \$2,500 for the opening up, repairing and deviation of highways within its limits. That owing to the want of experience of those entrusted with the work, lack of sufficient funds and the absence of uniformity and system as to method, the public do not realize the benefits it is entitled to expect from so large an expenditure as \$25,000 in ten years, as the condition of our highways in the fall and early spring, and the snow drifts in the winter amply testify. That the obstruction to, and sometimes absolute prohibition of traffic owing to the defective highways entail much annual inconvenience and loss to the farming, town and city communities, by reason among many others of the farmers being unable to team their products at a time when the highest prices obtain, and by reason also of them not being able without much inconvenience and loss, to keep up communication for other purposes, with those with whom they have business and social relations.

That, in the opinion of your petitioners, no more important duty can be undertaken, than that which will ensure speedy, safe and easy communication between the rural districts and the towns and cities and between the farmers themselves at all times of the year. That it is the opinion of your petitioners, that uniformity and system in road construction on modern and enlightened principles, are necessary in order to obtain the maximum of advantage to be derived from so large an expenditure on roads.

That recently the Province of Ontario has established the office of Provincial Road Instructor ; and in the opinion of your petitioners, this uniformity and system in road building may best be obtained by the Instructor's supervision, in connection with county roads commissioners ; provided Provincial aid be obtained in the payment of such work.

That the support of education, the poor, the erection and maintenance of county buildings, roads and bridges, administration of the laws, fire protection, lighting, water services and many other municipal necessities already entail as great burden on the local municipalities as they can at present well bear without incurring other financial liabilities.

That many of the States of the adjoining Union have adopted the principles of state aid to highways, with ever increasing advantage.

Thus the small State of Massachusetts in 1895 expended the large sum of \$600,000 in aid of this work. In New York State a bill recently became law to the effect that, on a petition to the county council, certain roads may be adopted as state roads. The petition is presented to the State Engineer and if it obtains his approval, he presents plans and specifications to the Legislature, and if approved by that body, fifty per cent. of the cost of construction is paid by the State.

In New Jersey the State pays three-tenths of the cost, the county six-tenths and the owners of the lands affected by the improvement, one-tenth.

In Connecticut any township may prepare plans and specifications and let the contract, under the supervision of the state commissioner, in which case one-third of the cost is paid by the state, one-third by the county, and one-third by the township.

In Rhode Island, California, Indiana and Kentucky, somewhat similar provisions exist, the principles running throughout all of them being, that the local municipalities prepare the plans, let the contracts under which the work is done, under the supervision of the state commissioner, on a uniform system so as to secure a permanent highway with the least expenditure, to which the states liberally contribute.

That, in the opinion of your petitioners, some method could be adopted by legislation by which the public may secure uniform and permanent highways, with protection from snow drifts, with the most economical expenditure of money, to be constructed under some general and competent supervision, in order that this Province may secure its full development and increase of population, and that it may not lag behind the States of the adjoining Union.

Your petitioners therefore pray That legislation may be adopted in order to accomplish the objects above indicated.

(Sgd.) JOHN C. REID,
Clerk of County of Dufferin.

(Sgd.) W. H. HUNTER,
Warden of County of Dufferin.

A LESSON FROM SCOTLAND.

Everywhere in romantic, hilly Scotland good roads are to be found, and only those who have travelled over them know the great measure in which they add to the real merits of the rural districts. Not merely in the well populated districts are the roads good, but in the craggy, mountainous parts as well, where sheep-grazing is almost the only possible means of utilizing the lands. When any portion of these roads is out of repair, the traveller may know that one man at least is not doing the work for which he is paid.

In Scotland farmers do not work on the road, but spend their time where they can do so to better advantage—on the farm. The repairing of roads is let by contract and is under the supervision of an engineer or inspector, the inspector advertising for tenders on so many miles of road. It is then the duty of the contractor to see that the gutters are kept open and the water drawn off, particularly in the fall and spring of the year. Broken stone is furnished him and, with a one-horse cart, he draws this wherever needed for patching, filling up hollows and ruts as they form. In this way the roads are kept smooth as a floor, so smooth that very rarely in Scotland is a farm conveyance drawn by more than one horse.

Roughly estimating, the settled area of Ontario approximates the total area of Scotland, about 30,000 square miles, while, the population of Ontario is about one-half that of Scotland. At the time when statute labor was abolished in Scotland—nearly a century ago—the population was less than the present population of Ontario, being then only 1,800,000, while Ontario has now over 2,000,-000 inhabitants. Ontario with respect to her highways is one hundred years behind Scotland, but is better able in wealth, population and experience to make rapid strides for their improvement. The seed of a better system and better methods is being scattered over the Province, and less than a quarter of a century should find us on equal footing in every respect with the older lands.

A COUNTY SYSTEM,

That every county municipality should undertake the management of its leading roads is very much to be desired in the interest of better roads. There are a number of good reasons for the introduction of such a system, which has been thoroughly tested for several years in the County of Hastings. During the past year it has been actively discussed in the Counties of Oxford, Wentworth and Victoria, and although decided action has not yet been taken, there is every reason to believe that, when better understood, the prejudice which at present exists in opposition to it, will cease to prevent its adoption.

Under county control a properly organized corps of men can be employed to build and repair roads. As at other employments they become experienced and do better work, and in the matter of repairs are ready to make them as soon as signs of wear appear.

By a county plan, uniformity in system and work will be secured throughout the various municipalities. Whereas under township control a diversity of plans is sure to be adopted.

In a county plan an experienced and properly qualified man could be employed to have constant supervision of the work, whereas under township control, each municipality cannot afford to pay the salary of such a man. Under every good system of government it is necessary to have responsibility centralized and defined, not divided and easily shifted from one to another, as it is now under the statute labor system.

Under county control machinery can be handled to better advantage as an experienced operator can be employed for each implement, and a better and more uniform class of work will be secured.

A township can manage its roads properly only by adopting a plan similar to that outlined under a county system. But by extending it over the county it becomes more cheaply operated.

A properly connected system of leading roads throughout the county will be obtained under a county system; whereas with each township working independently of those around it, this will be lost sight of.

There is no community of interest between the townships. In one township there is a certain leading road much travelled and well made and maintained. The adjoining municipality may for various reasons not consider the continuance of that road through it of so much importance as to warrant them in making an expenditure to benefit largely their neighbors who are obliged to travel over it.

If no greater expenditure is made upon the roads than at the present time, the rate will be reduced because most of the township expenditure is now placed on the leading roads; and the township will be relieved of these by a county

system. Under the county system the funds will be sufficiently concentrated to undertake durable work, and consequently these roads will be properly constructed and afterwards maintained at a less cost than at present.

A county road system equalizes the cost of maintaining leading roads. In every county within a certain radius of a market town, traffic constantly increases as the town is approached. The cost of construction and maintenance increases in proportion to the traffic. It is unfair to charge those living near the town with the cost of keeping the roads to support the traffic from a distance; so unfair as to cause discouragement and often withdraws support.

Property is very largely valued according to distance from the market, and the convenience with which the market can be reached. Property a long distance from the market is affected to a greater extent by the bad condition of the roads than is property very near the market. Good roads are therefore of greater value to townships a long distance from the market town than those in the immediate vicinity.

Under a county system proper road construction would be undertaken and the economic value of this work would be seen and appreciated by the people of the different townships. The well built roads would stand as object lessons, and would teach the better expenditure of the funds spent by the townships on the roads maintained by them.

STATUTE LABOR.

The demand for better roads has directed public attention to the merits and demerits of statute labor, and a general feeling in opposition to the system is accumulating and gathering strength, promising within a few years to make a radical change in the method of caring for roads.

Previous reports have dealt upon this aspect of the case to a considerable extent, so that it scarcely becomes necessary to again enter upon a detailed discussion.

The system, under certain conditions existing chiefly in pioneer districts, is doubtless one of the best which could have been adopted, and has done exceedingly good work. Provision has been made under the Municipal Act, however, for substituting more suitable methods where these conditions cease, as they have done in many localities.

For well populated districts, where more advanced principles of government should be applied, the system of statute labor is fundamentally weak from two main causes which bring in their train many abuses, and cause failure in the effort to improve the roads in a manner corresponding to increasing requirements. These causes are, first: That control is so scattered that no one can be held responsible for a proper expenditure of the labor and money devoted to roads:

And second : That the payment of a tax in labor is too vague and clumsy to meet modern conditions. Some pay the tax with honest work, while others, from various motives, do not.

From these two sources spring many important results ; neglected roads, injustice to the men who do honest work, misappropriation of labor and money, and similar abuses.

Under present conditions, all responsibility is, in the first place, distributed among the members of the council ; the council again distributes it among fifty or one hundred pathmasters. A considerable sum in the aggregate is annually spent by most townships in the way of money and statute labor, but so scattered is this, together with responsibility, that the people scarcely realize how large a sum is being spent ; and when mis-spent and squandered as it generally is, there is no one whom they can call to account. The councillors can shift responsibility from one to another and then to the pathmasters. The latter have nothing to lose, and so can merely shrug their shoulders when any improper or careless expenditure comes to light. Divided responsibility is never a successful form of government.

There should be a public servant having a position similar to that of a clerk or treasurer, who can be held responsible for the proper disposition of money and labor applied to the roads. It is the only means of securing the most beneficial and economical expenditure. The position must be made a desirable one, both from the fees and honor attached, in order that the best men may be secured, and in order that they will be sufficiently anxious to retain the office to give their best services in planning and supervising the work.

The number of enquiries received by the Roads Branch, respecting methods of replacing statute labor is constantly increasing, and strongly indicates a trend of public feeling which will shortly operate throughout the Province generally in remedying the present weaknesses—weaknesses which exist merely because the attention of the public has not heretofore been directed towards the necessity of reform. A communication received from the Clerk of Minto Township, Wellington County, together with the reply thereto, will afford an illustration of the feeling in this respect, and the reforms recommended.

HARRISTON, Nov. 14th, 1898.

A. W. CAMPBELL, Esq.,

Provincial Instructor in Road-Making, Toronto.

DEAR SIR,—We propose submitting a by-law to be voted on by the rate-payers of the Township of Minto at the next municipal elections for the abolition of statute labor, and as several methods have been talked of to replace it, I take the liberty of asking you to give us your views as to the best methods to be adopted.

The number of days statute labor in our township for the past year was 3,508 and it is proposed to levy a rate sufficient to raise an amount equal to about 50 cents per day, or say, \$1,750, to be expended in road improvements in addition to what is now spent, which is about \$1,100 exclusive of bridges.

What we would like your opinion about is the proper method of expending the money. Should it be expended by the Councillors, each acting as Commissioner for his own division; or would it be better to place it in the hands of one Commissioner, or several, not members of the Council; or should it be apportioned to the pathmasters to be expended in their several divisions?

I may mention that there appears to be the greatest opposition to the by-law on the grounds that the present system is good enough, that by the new system the work would not be so evenly distributed and that too much money would be appropriated for commissions.

From the extensive knowledge you have in all matters relating to road making and from a desire of our Council to put the matter in a practical light before the electors before having it voted on, we considered it highly desirable to obtain your opinion on the matter. Any further suggestions outside of what I have indicated in this letter will be fully appreciated.

Yours respectfully,

[Sgd.] W. D. McLELLAN,
Clerk of Minto.

TORONTO, November 17th, 1898.

W. D. McLELLAN, Esq.,

Clerk of the Township of Minto, Harriston, Ont.

SIR.—I am very glad to see that your council has taken the progressive step of submitting a by-law to the ratepayers, at the next municipal election, for the abolition of statute labor.

I think, wherever this move is undertaken, the same opposition which you mention is made, viz., that the money will not be evenly distributed throughout the township, as the work is at present. The chief weakness of the statute labor system is the very fact that the labor is so distributed or scattered that in no section can durable or substantial work be undertaken for the want of a sufficient amount of labor. If the labor could be concentrated and faithful service performed along a well defined plan, good results would be produced. But this would be impossible. The money can be distributed in the same way by returning to each pathmaster the amount collected in his beat; but this would be only a very slight improvement, as experienced by the township of Winchester, where, upon making the change, this plan was adopted.

To reach successful results, the expenditure must be concentrated. All of your roads cannot be improved in one year nor a few years, but the whole of your roads should be planned, the township divided into sections, and the money in each section spent in a methodical way by commencing on the more important roads at one or more important points in each section, as your council may decide, finishing any work undertaken in accordance with your general plan and extending this work from year to year until the whole is finished. Every man

in the section or ward cannot be benefited by the first year's expenditure, but under a well defined system, each year's expenditure will bring the improvement closer to him, until finally each ratepayer is served. It would be necessary to strive to raise your people above jealousies and prejudice, and, in the interest of the township, look beyond the present to the improvement a few years will produce.

Your proposal to raise the money by levying a rate equal to about fifty cents a day is right. This added to the \$1,100 will make a fund which, if judiciously expended, will in a short time work a wonderful improvement on your roads without incurring an excessive tax. I would suggest dividing the township into four sections of about equal area. In apportioning the expenditure to the different sections, the road mileage, extent and character of the travel, accessibility of the gravel or other road material, and the nature of the land surface, whether hilly or comparatively level, should be taken into account.

The division of the township into four sections will insure the ratepayers a fair distribution of the money to each part of the township. I favor the appointment and continuing in office of one commissioner to have charge of the expenditure on all roads and bridges, as well as the care and operation of all road-making machinery; such commissioner of course being an officer of the corporation and a servant of the council. He should report to the council with any recommendations before any work is done, and should proceed with the work only when authorized to do so by the council. Payment for all work should be made only upon the certificate of the commissioner.

As far as practicable, the council should prepare a plan and specification, classifying the roads according to their importance, and should specify width of grade, amount of crown, width and depth of gravel or broken stone to be placed on each, in order to secure, as far as possible, uniformity in work.

The commissioner should be a man of some municipal experience, familiar with the township, with some practical knowledge of handling men and directing work, as far as possible independent of outside influence, and who has sufficient interest in the township to secure his continuance in the position.

He need devote only such portion of his time to the duties of his office as the council may think necessary, but should be free at any time in the spring, fall or winter to make inspections and have such work done as may be needed during these seasons, or made necessary by snow storms, freshets or other emergency.

Such a man can be found in each township, but great care should be taken in his selection, as the success of the whole system depends on him. He need not be an expensive man, as his employment should be by the day, and as a general thing not more than six or eight weeks per year of his time is required. A fair rate, including horse and buggy, is \$2.00 per day.

In the spring of the year the commissioner and the council should make an examination of the roads proposed to be improved, bridges, culverts, etc., and then decide what work is to be done.

Specifications should then be prepared, and as far as possible all works of construction, such as hauling gravel, digging drains, building bridges and culverts, cutting hills, should be let by public competition. Contracts should be entered into and security given. All grading should be done by a grading machine, which is the cheapest, simplest and most economical way of doing the work properly and expeditiously. This machine should be owned by the township, and operated where directed by the commissioner, the commissioner being given authority to employ whatever teams and men are needed.

The same teams and men, as far as possible, should be retained during the season's work, as they thereby become proficient and produce better results. The time for doing this grading should be in the early part of the season before the roads become baked and hard. There are many minor details of the work which the commissioner will regulate after a little experience, and which will be of great service in improving the roads; and a year's experience will show that the expenditure which you contemplate, made in this way, will do a surprisingly great amount of work, and will indicate to your citizens that system and method are what is required to make good roads in your township in a reasonable space of time, without increasing the present taxation for this purpose.

The chief objection to appointing councillors as commissioners is that a change of council means a change of commissioners and a consequent change of methods and ideas of doing work.

Besides, there is the influence which ratepayers are ever willing to exert upon their representative to secure favors, and which experienced councillors know will seriously tend to cripple the very object which your proposed change is intended to accomplish, viz., concentration of expenditure.

The sphere of a council is administrative merely, and the execution of the work should be through independent agents.

The commissioner will relieve councillors from a good deal of worry and humiliation, consequent upon carrying out such works. In one commissioner for the township you have an official whose continuance in office would be similar to that of a clerk or treasurer whose duties are fixed by by-law, and costing no more than a commissioner in each division.

I have recently received a letter from the clerk of N. Monaghan, in which township a commissioner is appointed in each district, but this plan they do not appear to favor and are now making an effort to place the work in the hands of one commissioner.

In fact I think the letter may be of some information to your council, and have taken the liberty of sending you a copy.

This is a matter which should be clearly placed before your people prior to the day of voting, as unfortunately in many municipalities the change is not made simply because the ratepayers do not understand, before voting, the effect the change will produce. Had this plan been adopted ten years ago, with the liberal expenditure you are making (say \$28,000, or its equivalent, expended on such a system) I think the greatest opponent of reform must admit that the results in your township would be vastly better.

Should you require fuller information on any point connected with the proposed plan I would be very glad to discuss it with you, or if your council think I can be of any assistance in discussing the matter with the ratepayers I would willingly address any meetings you may arrange for that purpose.

Trusting to hear from you again with reference to the matter,

I remain, yours truly,

(Sgd.) A. W. CAMPBELL,

Provincial Instructor in Road-Making.

ROAD REFORM IN OUTLINE.

The following is an outline, in brief, of a system of road control which a great many townships in Ontario could consider with profit.

Do away with the statute labor roll entirely.

To raise the money required, levy a rate on the assessment of the township.

For road purposes, divide the township into a convenient number of divisions, usually four.

Apportion the money equally among the road divisions, keeping in view all circumstances, viz: Importance of roads, works needed on them, benefit resulting to the greatest number of people, amount of traffic, assessment, etc.

Appoint one township road commissioner to advise and consult with, and carry out the direction of the council.

The office of road commissioner should be similar to that of the township clerk or treasurer.

Councillors should not act as commissioners, as they are subject to undue influence from the ratepayers, and their term of office is uncertain.

A general plan for road improvement should be laid down by the council for the commissioner to follow.

This plan should specify the width to be graded, width and depth of road metal, character of drainage, etc., of all roads.

Roads of importance should not be less than twenty-four feet between the inside edges of the open ditches. No road should be of less width than eighteen feet.

Early in the year the council and the commissioner should go over all the roads to consider the work to be undertaken.

Work of construction, such as hauling gravel, ditching, and drainage, building of bridges and culverts should be done by contract, and supervised by the road commissioner.

No account for labor or material should be paid by the treasurer except on the certificate of the road commissioner.

Minor work and repairing should be done by day labor, only the road commissioner being authorized to employ, direct or discharge men or teams.

All roadmaking machines should be in the care of the road commissioner.

Only the road commissioner should employ, direct or discharge the men or teams needed to operate the machinery.

Should the council desire to interfere in any of these matters they can do so through the commissioner.

The same man and teams should be hired to operate the machinery for the entire season, or longer if possible, as they become proficient and do better work. This applies particularly to the operation of a road grader.

The commissioner should keep a pay roll to return quarterly to the council, showing who have been paid and the amount paid, the roll to be then filed for auditors.

This roll will act as a check on favouritism on the part of the commissioner. Work should be divided as much as possible among the residents of the township desiring it.

Work should be commenced with a definite end in view and continued systematically, from year to year if necessary, until the entire road mileage has been brought to a proper standard.

NORTH MONAGHAN - STATUTE LABOR ABOLISHED.

Enquiry made of the Clerk of the Township of North Monaghan, Peterborough County, elicited the following reply from Mr. G. W. Bennett, Clerk of the Township.

DEAR SIR,—In reply to yours, 31st August, I beg to state : North Monaghan, is a small township, about 13,871 acres with an assessed value of \$611,750, with between 35 and 40 miles of roads—a large proportion of which are earth roads. Situated as we are, adjacent to the town of Peterborough, a large number of our ratepayers are gardeners, butchers, milkmen, etc. In fact a majority of our ratepayers attend the market more or less three or four times a week all the year around. It can easily be seen how important it is to have the roads in a first-class condition, more especially as prices for produce usually incline upwards during the season of bad roads.

Our system now is commutation of our total labor, about 1,150 days, at 50c. a day. This is levied and collected as ordinary rates.

Our township is divided as equally as circumstances will admit into four districts, in each of which a commissioner appointed by the council has entire supervision.

As soon as possible after Court of Revision, I, as clerk, make a list of all parties in each division liable to pay the tax and amount of the same. Each commissioner is supplied with the list for his division, this for the purpose of making as equitable a distribution of the money as conditions will admit. This money is entirely expended in gravelling, i.e., hauling gravel and metal from pits, some of which are private and belong to the township, and dumping upon such portion of the roads as are graded and water-tabled to receive the same.

The gravel from private pits costs us ten cents per yard, that from the township pits infinitely less, so much so, in fact, that no township should have, if possible, to pay for road metal by the yard. Our commissioners find it a great advantage to use a rooter plough in the pits to facilitate filling, and from township pits they can select such material as best serves their purposes on the different kinds of roads.

In addition to the commutation tax, each year, in our estimates there is an appropriation made for gravel, grading and grants, i.e., to operate a road grader,

one of which we have purchased, and grants on boundary lines where we are required to give an equivalent for maintenance, and for repair and reconstruction of culverts and bridges, of which we have a large number.

All these works are directly under the supervision of the commissioners, as such occur within their respective divisions. All gravel is paid for on the certificate of commissioner who receives blank forms for that purpose.

Our council at an early date each year go over each district in company with the commissioner and suggest and lay out work to be undertaken during the year.

The method of letting jobs by auction tender also, is frequently adopted in cases requiring a larger expenditure than ordinary. This plan has been adopted, I may say, to facilitate the distribution of money as much as possible. In each case the contract is subject to the inspection of the commissioner in whose division the job is let, who reports on the same to the council.

Previous to this year we had a permanent gang of three men and two teams on the road grader who were controlled by the council. This method was discarded this year as it was found too much grading was done for the amount of gravelling, and time, too, was wasted going about from place to place at the dictation of any member of the council.

We this year only employ an operator, who has become an expert by practice, and is under the direction of the commissioner when required by him, who supplies teams and uses the grader when and where he can do so to the greatest advantage, observing to do no more grading than can be well metalled in any one year. I may here say that out of twelve scrapers belonging to the municipality previous to the purchase of a grader we can only get track of three, so little are they called for.

Our Council have a fixed rate of pay for all purposes, as follows:—

Commissioner	\$1 50	per day.
Operator on grader.....	1 25	"
Breaking stone or filling.....	1 00	"
Man and team for any purpose.....	2 50	"

Each Commissioner is supplied with pay sheets and a time book which he is required to fill up, and as soon as required, the Council provide sufficient money which is paid to the order of each Commissioner who distributes it according to his pay sheet. This pay sheet when properly signed and certified is returned and examined by the Council, then if correct is filed for the Auditors, or for future reference. This examination by the Council is a check upon anything like favoritism on the part of a Commissioner.

This year our appropriations were as follows:—

Commutation of statute labor for gravelling.....	\$550 00
Road grader operator.....	50 00
Bridges and culverts.....	400 00
Grants and miscellaneous.....	100 00
	<hr/>
	\$1,100 00

I may say that for 1898 I have not the complete returns from the Commissioners as to amount of work done, but for 1897—which would be about the

same—there was about $8\frac{1}{2}$ miles of highway graded and water-tabled at a cost of about \$34 per mile. A considerable portion of this will require the grader over it again as it was found that during the wet weather in spring and fall the “narrow tire” cut into the grade, making ruts. This year there was much less grading done and also at a reduction in the cost. In 1897 there were 2,083 yards of road metal, gravel, etc., drawn at an average cost, laid on the road, of 40 cents per yard.

There are other matters connected with our efforts to secure better roads, but I find this becoming too lengthy. However, although this may not be the best method of road construction one thing is certain, there is not a man of any importance in this township who would go back to the old statute labor way. There are a few kickers whom the Commissioners gave the go-by as not worth their salt. I find from direct communication with both Council and Commissioners, as well as a thorough knowledge of the condition of our roads, that until 1896 there was little or no work done in this municipality with a view of permanency. Now I find stretches of roads all over the township that will compare favorably with almost any street in the Town of Peterborough, where they have procured modern road-making machinery and approved methods.

Another thing, at a meeting of the Council last week attention was drawn distinctly to the fact that amongst other improvements none have stood out so prominently as that of employing two first-class men at the dumps when graveling, supplied with a shovel and two stone hammers. Another important observation I can make.

The Commissioner having control of the work can and does insist upon a uniform box on each wagon with a result that, almost without exception, all the old boxes that were good enough for statute labor have now been discarded and new dump boxes of uniform depth and length have taken their place. This is important in many ways; not only does the township get the full value for their money in material, but each man draws an equal share, and it facilitates the evenness of the gravel when dumped upon the road.

There is an agitation on foot now in our Council to have *one capable Commissioner* over the entire township, and if it is possible to cut loose from the patronage which these appointments give each Councillor and appoint one good man who can employ foremen when desirable, they think it would be a still greater improvement.

Our Council are divided upon the commutation method. Some hold the view, and I endorse it, that the abolition of statute labor and commutation entirely, levying a general rate sufficient to meet the appropriation as found necessary after the annual inspection—in the spring—would be a better way.

In conclusion I might say we hope to have it within our means to acquire a road roller and crusher, and also to see a “wide tire law” within a few years.

I have the honor to be, Sir.

Yours truly,

[Sgd.]

GEORGE W. BENNETT,

Peterborough, 24th September, 1898.

Clerk of North Monaghan.

8. If a grading machine is available, grade the roads which you intend to gravel before the time of statute labor, and use the statute labor as far as possible in drawing gravel.

9. A fair crown for gravel roads on level ground is one inch of rise to each foot of width from the side to the centre.

10. The road on hills should have a greater crown than on level ground, otherwise the water will follow the wheel tracks and create deep ruts instead of passing to the side drains. One and one-quarter inches to the foot from the side to centre will be sufficient.

11. Repair old gravel roads which have a hard centre but too little crown, and which have high square shoulders, by cutting off the shoulders, turning the material outward and placing new gravel or stone in the centre. Do not cover the old gravel foundation with the mixture of earth, sod and fine gravel of which the shoulders are composed. The shoulders can be most easily cut off by means of a grading machine.

12. A width of twenty-four feet between ditches will meet most conditions, with the central eight feet gravelled.

13. Wherever water stands on the roadway or by the roadside, or wherever the ground remains moist or is swampy in the spring and fall, better drainage is needed.

14. Look over the road under your charge after heavy rains and during spring freshets. The work of a few minutes in freeing drains from obstruction or diverting a current of water into a proper channel may become the work of days if neglected.

15. Surface water should be disposed of in small quantities; great accumulations are hard to handle and are destructive. Obtain outlets into natural water-courses as often as possible.

16. Instead of having deep open ditches to underdrain the road and dry the foundation, use tile.

17. Give culverts a good fall and free outlets so that water will not freeze in them.

18. In taking gravel from the pit, see that precautions are taken to draw only clean material. Do not let the face of the pit be scraped down, mixing clay, sand and turf with good gravel. There is a tendency to draw dirty gravel as it is the easiest to handle.

19. Gravel which retains a perpendicular face in the pit in the spring, and shows no trace of slipping, is generally fit for use on the road without treatment. Dirty gravel should be screened.

20. Plan and lay out the work before calling out the men.

21. When preparing plans keep the work of succeeding years in view.

22. Call out for each day only such a number of men and teams as can be properly directed.
 23. In laying out the work estimate on a full day's work from each man and see that it is performed. Specify the number of loads of gravel to constitute a day's work. Every wagon box should hold a quarter of a cord.
 24. Make early arrangements for having on the ground when required, and in good repair, all implements and tools to be used in the performance of statute labor.
 25. Do all work with a view to permanence and durability.
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THE BEST USE OF STATUTE LABOR.

Experience, wherever statute labor has been employed, has shown that it can usually be made most productive of good when used in teaming. Without a great deal of friction, wagon boxes of a fair size can be insisted upon, and honest loads drawn. Appropriations from the general funds should be so directed as to utilize as much of the statute labor as possible in this way; they should provide for the preparation of road metal; that is, the crushing of stone or the screening of gravel, or whatever preliminary treatment is needed to provide a good metal. It is better that a grading machine should be used on the road some little time before the gravel or broken stone is applied, and this is a matter which can be profitably attended to by the council. Draining, or a major part of it, and the construction of culverts are details which should be looked after, independently of statute labor. Townships which can anticipate statute labor by preparing the gravel, grading the roads with improved machinery, and constructing culverts and drains out of the general funds, using the statute labor in loading the wagons, teaming and spreading the metal on the roads, will obtain the most satisfactory results.

GRAVEL.

Councils very commonly give but little consideration to the matter of procuring gravel for use on the roads. Pathmasters are authorized to obtain gravel from a certain pit. It is paid for by the load, and the teamster performing statute labor is left to decide the size of the load and quality of the gravel. In the performance of statute labor horses are treated very mercifully, the smallest and oldest wagon is used, the laborer is "working for the Queen," and the result usually is that the owner of the pit obtains for half a load of boulders and turf, the price of a load of clean gravel. The only fair way to buy gravel is to purchase the pit outright. Test pits and borings can be made, and the quality and quantity of gravel obtainable estimated therefrom. Buying gravel by the

load is like buying water by the bucketful. Cases have occurred in which the money received for the gravel in a pit in the corner of a farm has amounted to enough to pay for the entire farm.

If the waste in this way ended with the extravagant amount paid for the gravel, the amount would be comparatively small. The great difficulty arises from the fact that the money that can be spent for gravel is limited to a certain amount. If only half a load is obtained for every full load paid for, only half the possible extent of road is gravelled and the roads suffer in consequence.

The gravel used should be clean, free from clay and sand, and if these are mixed with it in any quantity the gravel should be screened. If large stones or boulders are contained in the gravel it is a good plan to place a stone crusher in the pit and pass all the material through it. By having a rotary screen attached to the crusher the dirt and sand will be removed. Too much ~~streets~~ cannot be placed on the necessity for clean material. There is usually enough dirt on the road before the gravel is put on without going to the trouble of drawing it from the pit.

Some townships are wasting an enormous amount of gravel, and in a few years will have to face a serious difficulty—that of finding a substitute. There are townships now not far from that difficulty; which have for years been piling gravel on badly drained, badly graded, badly maintained roads. The immense hollows on many farms testify to the large amount of material which has been used, without forming in a single instance, a first class and durable road covering.

Gravel placed on a poorly drained, poorly graded road, the repair of which is not attended to at the proper time, is quickly rutted, and in the wet seasons of spring and fall, is mixed with the soil beneath, its usefulness as a road covering being thereby largely lost. But on the other hand, when the road is well drained, and graded, and the gravel is so laid upon it as to form a distinct coating, and ruts are repaired as rapidly as they form, the life of the gravel is very much extended.

There is a mile of road in a township of Western Ontario, which was first gravelled fifteen years ago, has had very little expended upon it since then in comparison with other roads in the vicinity, and is in splendid condition to-day.

The road is on clay loam having moderately good natural drainage. The roadway was graded and the ordinary open drains provided at the sides. Gravel was placed in the centre, dropped from the wagons in the usual manner without spreading.

An old man who lived on the road, having little else to do, was employed by the pathmaster for a small amount to work on the road. He took an interest in his work, kept the drains open; year by year as a new line of gravel was added,

he spread it so that traffic at once passed over it instead of turning to the roadside, ruts were made in the loose material, but with a rake he brought the gravel back until the wheel tracks were like a line of steel rails, hard and solid.

This work was done fifteen years ago, but the road, as has been stated, is to-day the best in the township in spite of the fact that less gravel has been placed on it. A little extra labor has thus effected a saving of gravel, which if extended to the whole township would double the life of the gravel pits now being rapidly exhausted.

THE ESSENTIAL FEATURE OF A GOOD ROAD—DRAINAGE.

The essential feature of a good road is good drainage. This is true in all climates, but it becomes absolutely imperative in Canada where rains are heavy, at seasons almost continuous, and attended in the winter, autumn and spring seasons with severe frost, snow and slush. Every rule has its exception it is frequently said, but the maker of roads can safely follow the principle under all conditions, that drainage cannot be too perfect: that where drainage is perfect there is a perfect road.

On first sight this statement may seem exaggerated. The impression has so long existed that, if we get a surface of gravel or broken stone piled on a ridge of earth we have built a road, it is difficult to adjust our minds to other principles. No doubt working with this object, many fairly good roads have been produced, but they are, in a measure, the result of accident rather than reasonable and clear-headed design. When roads are built with the fundamental purpose of doing so by securing perfect drainage we will be on the most direct and shortest route towards securing good roads. Much unnecessary labor and money will be saved, as well as much disappointment and dissatisfaction.

Doubtless the dweller in the country of sand will be inclined to think lightly of this advice, for he knows that, in wet weather, not too wet, his roads are at their best. He will be inclined, if he has never lived on clay lands, to think that advocacy of road building with such an object is a false doctrine. Yet even on sand lands the principle of good drainage is the principle of good roads.

An essential part of good drainage is to attend to the shape of the road surface. This must be crowned or rounded up towards the centre. The shape of the road will tend to throw off to the side, the water as it falls in rain, and the water of melting snow.

In addition to being crowned, the surface must be smooth; that is, free from ruts, wheel tracks, holes and hollows. If these exist on the surface of the road, instead of being thrown to the side the water is held back, is absorbed into the roadway which softens and yields readily to the wearing of the wheels. Like the water poured on a grindstone, so the water on a road surface assists the

grinding action of wheels. When the road is wet the holes and ruts rapidly increase in size, wagon after wagon sinks deeper, until finally the road becomes utterly bad and perhaps impassable as we so frequently find Canadian roads in late fall and early spring.

In order to provide for a smooth, round roadway, that will remain so in wet weather, it is necessary that the surface of the road be hardened with some stony material, and for this we use gravel and broken stone. By resisting wear, ruts and hollows do not form readily, or when commenced they do not increase with such great rapidity.

Having crowned the road and made it smooth, having placed on it a covering of metal to harden it, and assist in keeping it so, it is necessary to dispose of the water which flows from the travelled roadway to the open drains at the road side. These open drains must have an outlet to which the water flows readily and freely. Drains which have not a good fall and free outlet, which merely catch the water and hold it until it sinks into the earth, are of little service to the road. The reason for this points to another of the main features of good drainage.

That is, it is not sufficient that we crown the surface, make it hard and smooth, and carry away the surface water in open drains at the side of the road. It is absolutely necessary that the natural earth sub-soil which we crown and coat with stone shall be kept dry; for to keep the sub-soil dry is to keep it firm and strong to support the load. This metal, as we have said, resists wear; the natural earth underneath has to support not merely the load but the surface material as well. It is therefore, as previously pointed out, of prime importance that the water caught by the side drains shall be carried away immediately, before it can sink into, and soften the road foundation.

More than this, not merely must the surface water be carried away quickly, before it can sink into the soil, but underdrainage must frequently be resorted to. In many sandy and gravelly localities and even in clay districts, nature sometimes provides sufficient natural underdrainage, but more frequently we find low, wet sections where the water line must be lowered by means of tile drainage. A tile drain under each open drain is, in nearly every case, the best plan to pursue where underdrainage is needed.

The vast good which can be accomplished by means of tile underdrainage on the roads has been too long overlooked in Canada. Agriculturalists who have used tile underdrainage on farm lands, will be able to better understand its action on the roads. Just as there are lands which are useless for farming without underdrainage, so there are roads which are useless without underdrainage. A dry sub-soil can support any load. But with a wet and consequently weak sub-soil, the road metal is at once forced down and buried in the mud, while the mud

rises to the surface. And if the want of a firm dry foundation the crown of the road is destroyed and the earth is washed away, the road and the surface become soft and rough, easily worn, and sudden damage is likely to happen to vehicles.

Here then we have a test for the goodness of the making, which reveals themselves especially by a heavy fall of rain. A hard dry earth will not surface unless the water of the rain beats and the soil beats hard to get it away. The best way of testing is to lay a board across a road after a heavy fall of water or the rain, so as to form a dam at the lowest point. A board is far as I can see the best. The water will rise to the height of about a foot, and if found an inch or two shorter, we have probably found out that there is no all by means of a dam.

Sand must be used sparingly, unless in the case of a marshy soil, where the soil will be good and strong, and a little sand will make the strength increase; so also with gravel. It is a great advantage to have a gravelly surface, particularly in low and uneven places. But in every case of soil or of clay, except of the year the water has fallen, it is best that there should be nothing in the road. If water has got into the soil, which makes the subsoil damp, should be removed.

The next point to be considered is the quality of the stone to be used on our roads. This will depend upon the nature of the material. The upbearing of a road is a great deal more in the character of stone. Stone expands and contracts, and is liable to move. But it is better than the ground, and it is better to have a road made of stone, because it is more durable, and it is more likely to last longer.

The last point to be considered is the cost of the work. This is the most important point, and it is the one which is most difficult to estimate, because it depends upon the number of men required, and the cost of materials, and the cost of labour.

By comparing the cost of a road with the cost of a bridge, we may get some idea of the cost of a road. The cost of a bridge is the cost of the materials, and the cost of the labour, and the cost of the tools, and the cost of the horses, and the cost of the men.

The cost of a road is the cost of the materials, and the cost of the labour, and the cost of the tools, and the cost of the horses, and the cost of the men. The cost of a road is the cost of the materials, and the cost of the labour, and the cost of the tools, and the cost of the horses, and the cost of the men. The cost of a road is the cost of the materials, and the cost of the labour, and the cost of the tools, and the cost of the horses, and the cost of the men.

such a time, sinks farther into the softened track. Here is a deeper hole to hold water ; soon it becomes a rut, and the rut develops into a pitch-hole. The soil underneath is brought up and mixed with the surface covering. The surface covering is broken and forced down into the soil. Here then is a bad road and a permanent weakness, the result of neglect to repair the road at the proper time, neglect to keep the drainage of the road in perfect condition at all times.

THE ROAD GRADER.

During the past season in a large number of townships of Ontario, grading machines were used in improving the roads. That so many different methods of operating these machines should be employed, points strongly to the necessity of laying down a uniform system for regulating this important part of the work of road-making in order that the best results may be produced. A road grader is the most necessary implement for a township to possess, and in fact, some townships are so convinced of this as to have invested in four machines, placing one in each quarter of the township. The crowning of the roadway can be done very rapidly, cheaply and perfectly, by their use. To depend upon manual work for the first grading of roads, and the repair of others that require re-shaping, is a useless waste of labor and money. But these machines in the hands of inexperienced men, are often made to injure rather than improve the road.

The operator must know how a road should be made, and how the grader should be worked in order to make each road with the least expenditure. A study of the different methods employed, and a talk with the different operators, shows that the ideas are as varied as can be imagined ; many of them are so ridiculous as to make one wonder why they should be tolerated by any municipal management.

In one township the machine is purchased by the council, placed at the disposal of any pathmaster who sees fit to take it from the railway people, and of any other pathmaster who cares to take it from one beat to another. These men may have then seen the machine for the first time and know nothing whatever about its mechanism or how it should be operated.

The directions specify the number of teams for ordinary soil. The horses are attached and if they do not provide sufficient power others are added. The blade is plunged into solid clay full tilt as if the whole object was to determine its strength or test the merits of the different teams engaged.

Each pathmaster is permitted to plan the work to suit his own ideas, and these usually differ from those of the pathmaster of the next beat. The width of grade differs from 15 to 45 feet in the same township, and sometimes in the same beat. The amount of crown which should be given is, of course, arbitrary, and extends

from the flat and useless, to the ridiculous and dangerous. Roads are often graded higher where the crown is already sufficient, and occasionally the machine is used for ungrading a piece which is already properly made.

Another plan is for the council to hire the operator, the beats requiring his services to furnish the necessary teams, the work to be done according to the direction and dictation of the pathmaster, thus making the operator simply a part; the operator to be employed for the season's work only, and in fairness to others, the job must be passed around, so that he cannot expect to be hired for more than one season.

Sometimes the council employs the operator and one team, the beats using the machine to furnish the remaining team or teams. Where the township is divided into four wards or sections, one man and one team is sometimes employed in each ward so as to distribute the honors and patronage, these men to have charge of the machine in their respective wards. In townships more advanced in this work, the operator and two teams are employed by the council, he to appear when called on at any beat in the township even if he has to pass from one side of the township to the other. He is given no plan to follow, no directions, but is supposed to exercise his best judgment in the performance of the work; except where his judgment may conflict with the idea of the pathmaster, in which case the pathmaster rules.

Under all foregoing plans, no attempt is made at operating the machine during the early part of the season when the ground is in a fit condition, and when the work can be easily and properly performed; but the machine must remain idle awaiting the statute labor season when, as a general thing, especially in clay sections, the soil is baked so hard that perfect work cannot be done and it is unreasonable to expect satisfactory results. Often this work is commenced just when these roads are becoming serviceable and are ruined for the remainder of the summer. In such cases the investment is unprofitable, the labor is wasted, the roads are injured, farmers are deprived of services which are urgently required at this important season on the farm; and the benefits which would result from improvements upon the roads, if such labor was expended at a proper season and under suitable plans, is lost to the community.

The chief mistake in the use of a grader, and one which has caused a great deal of harm, is the covering of old gravel roads with the earth from the shoulders, in order to crown the road. This soft material at the edges of the road, clay, turf and washings from the road, is precisely what is not wanted on the travelled track. But this stuff is precisely what inexperienced men insist on putting on the road. These square shoulders are, of course, objectionable and should be cut off, as they interfere with drainage; but they should be thrown outward, across the ditch if necessary, and then the best gravel or stone obtainable should be used to crown the road and form the track. The reverse of this, rounding up

the roads with the material from the edges of the gravel roads has utterly destroyed many fairly good gravel roads. It appears almost necessary to let people destroy a few roads in order to show them what ought not to be done, and so convince them as to what should be done.

A proper plan to adopt would be as follows:—

1. Prepare a complete plan of the township, showing all road allowances, watercourses, bridges, etc.

2. Classify these roads according to their importance, dividing them into (a) main roads, (b) roads of moderate travel, (c) roads of least travel.

3. Prepare a proper specification fully describing the roads according to the above classification, setting forth the width of roadbed, plan of drainage, amount of crown, kind of material to be used as a covering, whether gravel or broken stone, depth and width to which it should be laid, how the material shall be prepared and applied, etc.

4. The grading machine should be owned by the township, one man should be employed to have charge of and operate the machine, and he should be a fixed resident of the municipality in order that his services may be retained for a number of years. He should be thoroughly practical and have some mechanical knowledge. He should be provided with a copy of the above specifications, and each spring, with a committee of the council, should examine the roads and determine the portion to be graded, as far as possible extending the work of previous years, securing continuity and uniformity in all work.

5. The operator should hire a sufficient number of teams to work the machine, and the same teams should always be employed in order that they may become accustomed to the work.

6. Where roads have already been gravelled, but the surface has become flattened by traffic and other causes, they should be carefully examined by the council, and all needed improvements can be then specified. As far as possible, the old gravel or stone roadbed should be preserved, and, except in cases where it is absolutely necessary to raise the grade, no earth should be placed upon it. But the shoulders should be cut off, turned outward and removed, and a new coating of metal applied to the centre of the road.

ROCK CRUSHERS.

Good roads and streets cannot be made perfectly and economically without the use of proper implements and machinery. In many municipalities gravel is scarce, and what is to be found is of very inferior quality, while stone for macadam can be easily and cheaply procured. In its natural condition the stone is useless

for streets, but properly broken, makes excellent material. For this work a rock crusher is required. Municipalities in Ontario are realizing this, and many have purchased complete outfits and are doing excellent work.

The cost of these crushers depends largely upon the capacity of the machine. The smallest make is usually chosen on account of its cheapness and without regard to the amount of work it will have to perform. The smallest machines are intended for township work, where they have to be constantly moved about and where the work at each point is not very great. With careful handling and not overcrowding, these machines, with necessary repairs, will answer for a number of years.

For city or town work, where a large quantity of material is required, it is a mistake to purchase a small crusher. The breaking of stones is a very severe test on machinery, owing to the varying character of the material; and ample capacity, so that the work can be done with perfect ease, is necessary. A crusher of ten cubic yards per hour run only at three-quarters its capacity, is the most serviceable and economical machine for most towns and cities. The extra cost incurred will prove a profitable outlay when the expense of maintenance and operation is considered.

There is frequently more than one way of doing a thing, but there is usually only one way which is the best way. To discover that one best way, even in doing so simple a thing as breaking stones for roads, generally requires some thought, knowledge and experience.

For example, some municipalities still cling to the oldtime method of breaking stone for roads, by the use of hammers and worn-out men who are pensioners on the municipality. There may be cases in which such a method is satisfactory, but they are very rare. Good labor is cheaper at any price.

In stone-breaking, there is no better laborer than a well-built, well-designed stone crusher. To operate the stone crusher, power is required however. Some municipalities, for this work, use an expensive steam roller attached to the crusher. The roller is made for one purpose, for compacting the metal in a road. To operate the motive machinery at so high a speed as is required for a stone crusher, to subject it to the jolting strains of a crusher, cannot but be very injurious to the roller. Of greater moment, perhaps, is the fact that the roller is unprotected from the dust created in crushing the stone, thereby causing great



THE POPULAR IDEA OF ROAD-MAKING MACHINERY.

wear. This illtreatment of an expensive roller will tend to destroy it very rapidly, the resulting depreciation being very great, varying, of course, according to the extent to which it is so used.

The cost of operating a steam roller for power (in addition to the deterioration of the roller), will cost about \$2.50 per day for fuel, and \$1.50 per day for an engineer.

Better than this is to purchase a separate engine which can be operated for about the same [daily outlay \$4. The value of the engine being much less than the steam roller, the resulting loss from depreciation is not so great. Some municipalities [have purchased second hand engines which have been used on threshers, for \$250 and \$300, and which have rendered very efficient service.

The town of Berlin, however, has one of the most economical sources of power in the Province. An electric motor, receiving power from the local electric plant, does the work for \$1.75 per day. The motor which cost \$250, is a small piece of machinery, requiring little care other than oiling and "pushing the button," when power is to be turned on or off. The motor is of very simple design, is protected from dust and weather by a small wooden covering, so that loss from depreciation is very slight.

A number of the American States have in various ways experimented with the employment of convicts in road-building, New York, North Carolina, and California being perhaps the chief. There are objections to having the prisoners employed immediately upon the roads in such work as draining and grading, objections which the majority of Canadians will readily appreciate. There are few who desire to see, in public, anything resembling chain gangs, guarded by armed keepers.

The spectacle is a degrading one, and can result in no good to the prisoners. The law has no part in avenging crime, but in preventing it. To elevate the criminal is the righteous and highest aim of justice. To publicly humiliate can have no such influence.

There is, however, a manner of employing convicts, behind the prison walls, which will at once give them healthful employment, take them away from competition with honest labor, and result in benefit to the roads. This is in the preparation of road material. Milton, Cornwall, and we believe other county[gaols, already employ the prisoners in this way, the stone being conveyed to the gaol, and broken with stone hammers. Much more, however, could be accomplished if stone crushers were used, and the broken stone supplied free, if necessary, for use on country, as well as town roads.

Where stone or gravel for road metal is not readily available it can be frequently shipped a considerable distance by rail at a reasonable rate. Complete crushing plants are now[operated, and have been in operation for the past few years, at St. Davids, near Niagara Falls, and at Hagersville. Considerable material is

being supplied to different municipalities by these quarries. In western Ontario gravel and stone in many sections, is scarce, but a large crushing plant has been placed in the quarry at Amherstburg, from which an ample supply for all such sections may be obtained. The railway companies are all disposed to grant reduced rates to municipalities on material required for roadmaking.

It would be advisable for municipalities without road metal to obtain prices, and strive to divert as much as possible of their annual appropriation for the purpose of providing such material, leaving the statute labor or other expenditure for hauling and placing it. Many municipal councils consider this too expensive an undertaking, to even consider, but would be surprised to find, taking all things into consideration, how cheaply roads can be made in this way.

"A STEAM ROLLER AN ABSOLUTE NECESSITY."

The usefulness of a steam roller in the construction of broken stone roads, has been fully commented upon in previous reports. An article under the above title appeared recently in the 'Brantford Expositor,' fully corroborating from entirely independent sources, and in an entirely independent manner, all that has been urged with respect to steam rollers, and is most instructive. The article indicates, too, the widespread interest taken in street improvement, and is as follows:—

"The 'Expositor' makes no pretence of being a scientific expert in the matter of road-making, but is prepared to accept experience both in this, and in other lands, as determining that a steam road roller is an absolute necessity in the economical construction of macadam roads, and in their repair. This is abundantly demonstrated by the fact that in countries, and municipalities, where the best macadam roads are to be found, this appliance is always present.

"In our own Province of Ontario the movement in favor of good roads has been advancing rapidly, and simultaneously there has been a demand for proper machinery. The following cities and towns have purchased steam rollers:—

Toronto	London	Hamilton	Chatham	Stratford
Berlin	Galt	St. Catharines	Niagara Falls	Ottawa
Brockville	Woodstock	Owen Sound	Kingston	

Peterborough council has decided to make the purchase, and in St. Thomas a steam roller is owned by a contractor.

"The very fact that almost every Ontario municipality occupying a similar position to Brantford is in possession of this valuable aid to good roadmaking affords strong evidence that such an appliance is an absolute necessity for this city.

"The purchase of a steam roller was one of the strong recommendations made by Mr. Campbell, the Provincial Road Commissioner, in his report of the 30th October, 1897, on Brantford streets, and the same excellent authority in a letter to the editor of this paper of recent date says:

"SIR,—Your favor of the 11th inst., making enquiry as to the utility of steam rollers, was duly received.

"From the list which I sent you, you will see that Brantford is one of the few cities in Ontario which does not own or use a steam roller in the building and maintaining of streets, and, in fact, very few of the larger towns are without such an implement.

"I am satisfied that every municipality using a steam roller will unhesitatingly say that it is indispensable in the proper construction of streets. No one with any experience in street-building will assert that the work can be done with any degree of satisfaction without a roller.

"In building streets, as in any other class of work, proper implements are necessary to secure perfect and economical results. Without a roller the practice is to excavate and grade the roadbed, then dump the gravel or broken stone on this soft foundation. The material not being compressed will yield to the wheels, rut, separate, and roll about. To prevent this in a degree, sand, cinders, or other foreign material is mixed with the stone and spread over its surface, to fill the voids and act as a 'binder.' This, however, is only temporary work, and lays the foundation for most expensive maintenance, besides proving a very unsatisfactory roadway.

"The sand, ashes, cinders, etc., placed on the surface grinds into dust in the dry weather and becomes unbearable if not constantly sprinkled, and this is difficult to do without converting it several times a day into a body of mud.

"The extra sprinkling is a considerable item of cost, and the mud created is very annoying to the users of carriages and bicycles, as well as being injurious to these vehicles.

"This foreign material in the body of the roadbed attracts moisture at wet seasons, turns into mud, and the bond between the stones is broken, causing them to yield to traffic and turn into ruts and holes. This mud churns to the surface and yields a very heavy crop every season, which must be scraped up and carried away.

"In a properly constructed road, after the excavation is done, and before any stone is placed upon it, the foundation should be rolled until perfectly solid. Upon this the broken stone is placed. This stone should be graded by the screen attached to the crusher into three different sizes, the coarsest being placed at the bottom of the road and the finest at the surface. In crushing the stone, a large quantity of fine stone dust is created, which is removed by the screen, and only this dust should be used for the binder, a sufficient amount of it to fill the voids being scattered over each layer of stone placed on the road and also on the surface.

"Each layer should be rolled sufficiently to set the stones in place, and after the final coating is put on, the rolling should be continued until every stone is firmly set and the mass perfectly consolidated. Each layer should be sprinkled with water before rolling so as to wash the stone dust into the crevices. In this way a road is made of proportionate thickness and uniform strength on an unyielding foundation, impervious to water, with a smooth, hard surface which will readily shed the water and distribute wear and traffic uniformly.

"It is the only way to construct a macadam road in the cheapest, most efficient and economical manner. It can at once be seen that this cannot be accomplished without the use of a heavy roller. For city work, such a roller should be about fifteen tons in weight.

"In constructing a macadam street, the stones are broken into cubical fragments and placed to such a depth as may be required to withstand the traffic. If this stone is dumped loosely on the road each stone lies separately, there is no proper union of the mass, and in wet weather the water passes through the stone as through a sieve, enters the foundation and converts it into mud. The traffic then settles the stone into the weakened foundation, forcing the mud through the voids to the surface.

"Whereas, where a roller is used, its repeated operation over the surface of the stone causes each cubical block to find its place among the cubes below it, forming a perfect combination, keeping them together and filling the voids. By the aid of sprinkling and pressure, the whole is cemented and forms a perfect sheet of clean material, almost equal to solid stone.

"For the sake of appearance and cleanliness the principal streets in the business part of Brantford should be paved with a more substantial material, such as brick or asphalt, but the standard pavement for Brantford, as well as other cities and towns in Ontario, should be properly

constructed broken stone roads. Your city now owns a crusher, but the usefulness of this valuable machine is largely lost for the want of its complement, the heavy roller. By providing this you will have made an important step towards the improvement of your streets.

"As the use of heavy rollers in street construction in Ontario is of recent date, it will be interesting for you to obtain, as you contemplate, the experience of other towns and cities using them."

"The *Expositor*, as Mr. Campbell indicates in his letter, did take steps to obtain the opinions from cities and towns which already own steam rollers, and in no instance was a reply unfavorable to their use obtained. On the contrary, all the authorities were in agreement that good roads could be obtained in no other way. We append the replies thus far received :

From C. H. Rust, City Engineer of Toronto :

"DEAR SIR,—In reply to your letter of the 11th inst., it is impossible to make a good macadam road without the use of a steam road roller, and, if the city of Brantford is building macadam roads, I know no better investment for their money than a steam road roller."

From E. G. Barrow, City Engineer of Hamilton :

"DEAR SIR,—In answer to the question asked in yours of November 12th, I would say that our steam road roller has given very great satisfaction. It has been in constant use since we purchased it, and our macadam streets have been done far better and much cheaper than heretofore without the roller. In picking up rough macadam streets it has done as much work in a day as twenty-five or thirty men, and its use in rolling the foundations to receive the macadam is very great, making a compact bed. I cannot speak too highly of the work of the roller, and I can say with the utmost confidence that our city never spent money to better advantage."

From Robert Surtees, City Engineer of Ottawa :

"DEAR SIR,—In reply to yours of the 12th asking experience of this city with steam road roller, I beg to state that this city has had a fifteen-ton steam road roller for the past ten years, and consider it one of the best investments they have made. In my opinion it is impossible to make good macadam roads without using a ten or fifteen-ton steam roller, and prefer fifteen-ton."

From A. Ormsby Graydon, City Engineer of London :

"DEAR SIR,—In reply to your enquiry as to the benefit or otherwise to the city of having a steam roller for assisting to make good roads, I beg to say that it is not possible to make a good macadam road without one, and for ordinary gravel roads the roller is of immense value. In my opinion and experience no corporation making gravel or macadam roads can afford to do without one.

"I have had one in use for about three or four years and have found it of great advantage, in fact, for a portion of the year I would be glad to have two of them. The season is short in which you can use it, about six months, and we can hardly roll all the streets required to be rolled in that time, as there are 118½ miles of streets in the city."

From Jas. A. Bell, City Engineer of St. Thomas :

"DEAR SIR,—In answer to yours of the 12th, I beg to say that this city has no steam roller and has only used one under contract for laying brick pavement. All our other streets have been made with a five-ton horse roller, which is owned by the city. I may say that from experience much better work can be done at less cost by using a steam roller."

From W. Bolger, City Engineer of Kingston :

"DEAR SIR,—In reply to your letter of the 12th inst., I beg to state our steam road roller is considered the most convenient and useful article the city owns.

"The one we have has been in use for twelve years, and is now as good as ever. Your city would make no mistake in purchasing a road roller if you have much macadam streets. We would not be without one for any consideration."

From W. F. Van Buskirk, City Engineer of Stratford :

"DEAR SIR,—I have the honor to acknowledge receipt of your letter of the 12th inst., re experience with steam road roller.

"You will find a report on the matter written by me for Mr. Campbell, Provincial Instructor in Road Making, in his report for 1897.

"I am of the opinion that good macadam, gravel or earth roads cannot be made without a roller, but it should be borne in mind that a roller itself will not make good roads. It is like any other machine, requires skilled labor to operate properly, and intelligent management to secure the best results.

"The work done here on old gravel roads has been satisfactory, and has been done at a low cost. Old gravel roads have been torn up, regraded and thoroughly consolidated, making as good roads as could be made for four times the cost without the roller.

"A roller is necessary for the repair of roads, as new material can be so easily incorporated with that already in place.

"I was greatly amused at the ideas of the laborers at the time the roller was purchased here. They were of the opinion that the machine would not do the work that they had been doing, and opposed purchase for that reason.

"I consider a steam roller a necessity for any town doing road work by day labor. The question of weight necessary should be left to the engineer and not to the agents of the firms wishing to sell machines. The engineer will know what weight is best for the class of soil and material available, and as he will be held responsible for work done, let him choose the machine he wishes. This is important."

From George A. McMullen, Town Clerk of Brockville :

"DEAR SIR,—Replying to yours of 12th inst., would say that we have a fifteen-ton steam roller and would not be without it under any consideration. We now have street beds which are giving satisfaction in every way. I may also state that outside places such as Cornwall and Township of Elizabethtown have rented our roller with the result that they have decided on having rollers of their own.

"We purchased ours from Kelly Bros., Springfield, Ohio, U.S. (firm name the O. S. Kelly Co.). I understand, however, that steam road rollers can now be procured from Canadian agents at a less price than ours cost in 1894.

"Any further information you may require will be cheerfully given."

From J. M. Hood, Clerk of the Town of Galt :

"DEAR SIR,—Replying to your letter of 12th, the Town of Galt has a Buffalo Pitts Steam Road Roller, and it has been in use nearly all summer on our streets. It is the universal opinion that we have more to show for the money spent on our streets this year than for years before on the old tinkering plan. We have a stone crusher and all the other appliances for making good roads.

"We are especially well pleased with the roller. It is a fifteen-ton one, and in every particular fills the bill.

"Any further particulars will be pleased to give."

From John Robinson, Clerk of the Town of Niagara Falls :

"DEAR SIR,—In reply to yours of 12th, I have no hesitation in saying that the steam roller lately purchased by the town of Niagara Falls has materially contributed to the making of good streets. The steam roller was bought in the latter part of 1897 from the Buffalo Pitts Company and has given perfect satisfaction. This year the town bought a stone crusher, and with these two machines has made the road along the river front the best road we ever had in the town. After seeing the work of the roller and crusher I do not think there is a man in town who would consent to do without them."

From H. Aletter, Town Clerk of Berlin :

"In reply to your letter of 12th inst., I beg to say that how to make good permanent macadam roads without a roller is beyond our comprehension. We are just now using our roller on one of our leading streets, which street we constructed in manner following :

- "(1) Lay four inches cobble stones.
- "(2) Lay four inches coarse crushed stone.
- "(3) Lay four inches fine crushed stone.
- "(4) Lay one inch dressing (fine gravel).

"This street is partly finished and we are all of the opinion that we have an A1 street in every respect.

"We have nothing to show for the vast amount of money spent on our streets heretofore without the use of a roller.

"We have also been using our rollers on old worn-out streets by way of picking up and rolling down roadbeds with quite satisfactory results."

"The *Expositor* has withheld no letters it received in reply to its question; it has given every letter precisely as it was received. Such an emphatic endorsement of the use of the steam roller cannot be safely disregarded by any thinking elector, particularly by one who is anxious, as all should be, to see that proper return is secured for the money expended on our streets, and that the city in which we take so much pride shall fully deserve, in all respects, the claim we are continually making for it of being progressive and up-to-date. It is false economy to work with poor tools, and this applies to the making of corporation streets as it does to everything else. A steam roller will pay for itself many times over, and the investment cannot be made too soon.

"We are satisfied that if the ratepayers of Brantford had been seized of all the facts when they voted upon the steam roller last summer, the result would have been vastly different. It would probably have been different as it was, had not two other by-laws, one for a very large amount, been submitted at the same time, and thus created a certain amount of hesitancy lest expenditures were being pushed forward too rapidly. We are convinced at any rate that a mistake was made at that time which cannot be too soon corrected, and that it will pay the Council to borrow a steam roller rather than continue as we have been doing in the past. It is worth considering, indeed, if another by-law should not be submitted to the electors in January next, and we feel satisfied that if this be done the proposal will carry by a good majority."

THE WEIGHT OF THE ROAD ROLLER.

There are different kinds and classes of rollers. The horse roller weighing six or eight tons, will do fairly well if a steam roller cannot be afforded, but the horse roller is not sufficiently heavy and has to be used much longer on a given section than has a steam roller to produce the best results. The feet of the horses, in exerting sufficient strength to move the roller, sink into and disturb the road metal, and thereby injure the shape and quality of the roadway.

There is danger, on the other hand, of having a steam roller which is too heavy. A very heavy roller will sometimes sink into light or loose soil, force it ahead and create a mound over which it cannot pass; this, however, may sometimes be overcome by spreading over the surface of the soil being rolled, a thin

coating of gravel. The same result will sometimes occur with an excessively heavy roller on a layer of loose stone. The heavy roller is more liable, too, to injure underground pipes, catch-basins, culverts, bridges, or disturb sidewalks.

For these reasons a roller exceeding ten or twelve tons in weight, in some localities where the soil is of a loose or sandy nature, is frequently not desirable. In districts where the natural soil is gravelly or of a stiff clay, a heavier roller may be operated successfully, but some municipalities have found it necessary to use a light horse roller in consolidating the sub-soil and first layers of stone.

Nor, if the stone used in the construction of macadam streets is of a soft nature, is a heavy roller say of twenty tons desirable even in the finishing courses, as the crushing effect has been found in some cases to crumble and pulverize the stone rather than merely consolidate it.

For new work, in which the dirt foundation must be rolled, a weight of twelve tons is generally the most serviceable; but for picking up an old roadway and reconsolidating it or for finishing a new work, fifteen tons is better. Where a town is to own only one roller it will be advisable to consider very carefully the work to be done before purchasing a roller of over twelve tons weight.

REPAIRING WITH A ROLLER.

By proper attention and repairs the life of a broken stone pavement can be made continuous. The surface can be frequently rolled, improving it greatly. It can be scraped and swept as are other pavements. When it begins to lose shape the surface can be loosened up by means of teeth attached to the roller, a light coating of new metal applied, and then rolled down as well as when new. It is by such means as these that broken stone roadways can be made more economical and satisfactory than any other for streets generally. This ease of renewal and repair is a property peculiar to macadam, which renders it most suitable for general purposes—that is, for residence streets. While the cost in the first instance may nearly equal that of cedar block, yet at the termination of the period when cedar block is decayed and has to be torn up and renewed, the macadam, if properly treated, is still in good condition. It forms a permanent basis, and its perpetuation is merely a matter of repair to be met by the general funds. Except under excessive wear or where in business sections a high grade pavement is necessary, broken stone pavements, by the aid of a steam roller, are beyond doubt the most serviceable, economical, and give the greatest satisfaction to the taxpayer.

HIGHWAY CULVERTS AND BRIDGES.

The majority of Canadians, when visiting Europe, are impressed with the durability and solidity which characterizes the structures of that country. Private residences are built to withstand the wear of centuries. Cathedrals,

public halls, libraries, and similar civic institutions are constructed, not merely for the present, but for future generations. Among the works marked by this durability are to be classed the public highways with all that pertains to them. Canada in this regard, presents a very unfortunate contrast.

It can justly be argued that Canada is a very young country, and that England is a very old country ; that Canada is not a wealthy country, and that England is a very wealthy country. While England is, in a way, a very old country, yet it is not so much older than this country in the arts of civilization, which should teach our citizens and municipal councils the necessity for and the means of wisely spending money in permanent improvements. And while England is a richer country than Canada, that greater degree of wealth has been brought about, to some extent, by the very durability which we have so long avoided. Permanent improvements are the cheapest. Structures which need props and repairs within a year or two after they have been built, seem to be in a chronic state of starvation, with a ravenous appetite for money. Canadians have not yet entirely outgrown the idea that they live in a pioneer land where the needs of the present entirely overwhelm the future.

In nothing is this temporary building more apparent than in our highways ; and in no detail of our highways is it more striking than in the matter of bridges and culverts. At the same time there is no portion of the making of a road that offers more scope to the roadmaker than in providing substantial and permanent waterways. Instead of the handsome stone and concrete arches that span so many of the streams intersecting the highways of England, there are to-day in this country scores of wooden boxes and trusses,—flimsy, disjointed, unsafe ; the constant source of accident, and the bottomless pit into which councils are annually throwing money in a vain endeavor to keep them in repair.

Location.

Considerable attention is generally paid to the selection of a good site for a bridge, and an effort is made to decide 'n the interest of economy, usually with a considerable measure of success. There is, however, a tendency to cling to the line of original survey, rather than deviate the road slightly, when by doing so, much would be gained in lessening the dimensions of the bridge, securing firm foundations for piers and abutments, reducing the cuts and fills at the approaches of the bridge ; all of which, while they may not decrease materially the first cost, very frequently are of the utmost consequence with regard to maintenance, and may decide for good or bad the usefulness of the entire roadway. The utility of a road with respect to hauling heavy loads, is not governed so much by the condition of the best section as by the worst ; not so much by the level portion as by the steepest grade. Bridges, forming as they do a means of crossing valleys, are intimately associated with the problem of judiciously choosing between directness of route, easy gradients and details of construction.

The location of culverts is a matter of very common error. Water should be disposed of in small quantities, along natural watercourses, before it gathers force and headway. Instead of this principle being followed, water is frequently carried long distances by the roadside, past watercourses after watercourse, rather than build a culvert or culverts to carry it away without injury to the road. Where culverts are needed, they should pass directly across the road and carry the water away from it.

The size of bridge or size of culvert involves nice discrimination, in which local circumstances and the class of construction introduce various factors. For the size of waterway, no hard and fast rule can be given. Many existing culverts and bridges were at one time of sufficient size, but the clearing, draining and cultivating of the land now permits the water after a rainfall to reach the watercourse in a shorter time with increased volume, causing submerged roadway and flooded roadsides, while culverts and bridges are swept away. The best guide to a proper size of waterway is an intimate acquaintance with the locality or the evidence of others who are, with respect to maximum rainfall, height of water line, previous experience as to floods, form and inclination of the stream and area to be drained, kind and condition of the soil and similar details. Talbot's Formula, proposed more as a guide to the judgment than as an unalterable rule is at times very useful:

Area of waterway in square feet = $C \sqrt[4]{(\text{Drainage area, in acres})^3}$. C is a variable co-efficient and the values given are :

"For steep and rocky ground, C varies from $\frac{2}{3}$ to 1. For rolling agricultural country subject to floods at times of melting snow, and with the length of valley three or four times its width, C is about $\frac{1}{2}$; and if the stream is longer in proportion to the area, decrease C. In districts not affected by accumulated snow and where the length of the valley is several times the width, $\frac{1}{4}$ or $\frac{1}{3}$, or even less, may be used. C should be increased for steep side slopes, especially if the upper part of the valley has a much greater fall than the channel at the culvert."

Waterways should be neither needlessly large, nor of too small dimensions, involving on the one hand unnecessary expense for first construction, and on the other hand, injury to the road, washouts, expensive repairs and delay to traffic.

Materials.

The materials available for culvert construction in addition to timber, are sewer pipe, concrete pipe, iron pipe, brick, stone and concrete. Culverts are sometimes made of one of these materials alone, or of two or more in combination. When the dimensions of a bridge are reached, concrete and stone abutments and piers, with iron or steel superstructure; or stone, brick or concrete, alone or in combination, are the materials gaining favor.

Sewer Pipe.

For the small culverts, sewer pipe is very economical and durable if well laid. To render them secure against the test of a Canadian climate, they should be laid with a good grade, and the ends protected with concrete, stone or brick headwalls having deep aprons. The joints should be made water tight with cement. These precautions will provide against the action of frost and will prevent the culvert being undermined by water passing along the outside of the pipe, either from the ends or through the joints. Care should be taken to excavate a concave bed for the pipe to rest in, always laying the spigot ends up grade.

The pipe at the outlet should be set flush with the surface of the ground. If set higher than the surface the fall of water will wash out a depression and will in time undermine the end of the culvert. A too rapid grade will cause the same result. It is frequently well to cobble-pave the outlet, where this undermining action is likely to occur.

Cement-Concrete Pipe.

Excellent culvert pipe of concrete can be manufactured cheaply in any gravel pit under the immediate direction of the municipal engineer. The pipes are from two to four inches in thickness according to diameter; which latter may safely and conveniently reach three feet, in lengths of two and one-half feet.

The implements required are of the simplest kind. The most important are two steel, spring cylinders, one to set inside the other, leaving a space between the two equal to the thickness of the finished concrete pipe. By "spring-cylinder" it may be explained, is meant such a cylinder as would be formed by rolling an iron plate into a tube without sealing the joint. With the smaller of these cylinders the edges overlap or coil slightly; but are so manufactured that the edges may be forced back and set into a perfect cylinder.

These two cylinders with joints flush are set on end, the one centrally inside the other and on a firm board bottom. The concrete, made of first-class cement and well screened gravel in the proportion of one of cement to three of gravel, is then tamped firmly but lightly into the space or mould between the two cylinders. The tamping-iron used to press the concrete into place is so shaped as to fit closely to the cylinders.

The concrete is allowed to stand in the mould for a few hours, when the cylinders are removed; the outer and larger cylinder by inserting an iron wedge into the joint, and forcing the edges apart; the inner cylinder, by inserting the wedge into the joint and turning the edges so as to allow them to again overlap, returning to the shape of a coil. The outer cylinder having thus been made larger and the inner one smaller, they can readily be taken away, and the concrete pipe is then left until thoroughly hardened.

Just such a number of pipe as are actually required for the season's work need be manufactured; the implements required are inexpensive, and the pip-

may be made by the municipality for actual cost, which, after a little experience, can be reduced to a very small amount. Culverts of concrete pipe are laid in a manner similar to those of sewer pipe.

Arch Culverts of Stone and Concrete.

There is no departure which would more enrich the highways than the general use of stone and concrete for the construction of bridges and culverts. They cost more in the first instance, but the longer life, the fewer repairs needed, the greater convenience, the lesser liability to accident, render them in every way desirable.

Concrete and stone are the only materials with which really permanent work of this nature can be constructed. Bridges and culverts of rubble masonry have existed in Scotland and Ireland with scarcely any repairs for more than a century, since before the time of Telford and Macadam. Concrete bridges and roadbeds built by the Romans nearly 2,000 years ago are still in use in spite of efforts to destroy them in military operations. The cost of this class of work is constantly decreasing through the cheapening and improving of cement, through the lessened expense of procuring stone and crushing it, and through growing experience in the use of cement. In Scotland it is common for farmers to contract for rubble concrete bridges, provide the stone, and hire masons to do the work. In this way the entire expenditure is kept in the locality, among the people who pay the taxes, and is therefore, in spite of a slightly greater cost, not unpopular. Up to forty foot spans, this construction is not difficult.

In the construction of a stone arch the first consideration is the foundation. The depth to which the excavation must be made will depend chiefly upon the span of the arch, and the nature of the natural soil on which it will rest. The chief object is that it shall be secure. If bed rock comes to the surface it may be safe to rest the base of the arch upon it without any further excavation. A firm hardpan may exist a short distance below the surface of the ground. But a quicksand, or other insecure footing, may necessitate the sinking of piles, or the placing of a wide, and perhaps deep, concrete base. But the foundation must be sufficient to provide that the washing of water cannot undermine it, that the lateral thrusts of the embankments cannot move it, nor that the weight of loads cannot cause it to sink. No more definite rule can safely be given than to make the most of local circumstances, with always a fair margin for safety.

Full-centre arches, that is, entire semicircles, are easily formed, possess great strength, and have little lateral thrust, but with wide spans, they necessarily rise to a correspondingly great height, and cannot always be employed. A segmental or flat arch will lessen the rise, but has a considerable lateral thrust which necessitates very strong abutments. A compound arch, made up of a number of different circles, when rightly proportioned, combines the advantages of the two, reducing the height, and at the same time having an excellent appearance. The

thickness of the arch and abutments depends upon a number of details, the chief of which are : the form and size of the arch, the quality of the material composing it, and the character of the workmanship. The haunches or shoulders should be built from the spring of the arch half way to the top.

With regard to the masonry, first-class hydraulic cement should be used. The arch stones should be full-bedded in cement, and each course afterwards thoroughly grouted. Each stone should be cleaned and dampened before being placed in the arch. Improperly dressed stones should be re-cut, as no hammering should be allowed after the stones are set. The ring-stones should be dressed into a wedge shape, so that they will radiate truly from the centre of the circle, and should be so dressed that the joints need not exceed three-eighths of an inch in width. The ring-stone should be of such thickness as to expose ten inches on the inside or face of the arch. The exterior of the arch should be flushed with a one inch coat of cement and the surface then smoothed off.

Arch-culverts and bridges of cement-concrete can be more cheaply constructed than can masonry arches, and if careful workmanship is employed, are quite as serviceable. They are formed by constructing a curbing and thoroughly ramming the concrete into it in successive layers. The manner of mixing the concrete depends upon the character of the cement used, some cements being slow setting, others quick setting ; some will set in water, while others will not ; some will allow a considerable portion of water to be used in forming the mortar, while other cements should be but slightly moistened.

One feature in connection with concrete culvert work is that, with the curbing and centres in place, an intelligent workman can, by following the instructions of the engineer, lay the concrete. Manufacturers complain that masons, in the great majority of cases, entirely disregard the instructions given them with respect to the mixing of cement, and follow their own methods of mixing common mortar ; while a man totally unaccustomed to work of this description will obey instructions carefully and minutely. Concrete cannot be mixed and put in place like common mortar, and by overlooking this fact, much concrete work has failed and has brought the material into disrepute in some localities.

Bridge Abutments.

The most substantial substructures of bridges are of either stone or concrete. In their construction sufficient excavation must at first be made to properly contain the abutments, and this earth may be refilled again so as to form approaches to the bridge.

The excavation completed, when concrete is used in whole or in part, the portion thus constructed must be boxed and curbed in a substantial manner the exact size and shape required. After the concrete has set, this boxing is removed and earth filled in solidly around the face of the abutments. Hammer dressed stone should crown the concrete to form a bridge seat.

Concrete should be composed of first-class cement; a clean sharp silicious sand, entirely free from earthly particles and coarse enough to pass through a twenty mesh and be retained on a thirty mesh sieve; clean screened gravel the largest not to be more than two and one-half inches in diameter; or in place of gravel, broken stone that will pass through a two inch ring. These materials should be mixed in the proportion of one of concrete, two of sand, and three of gravel or broken stone, with just sufficient water to form a plastic mass. The sand and cement should first be thoroughly mixed when dry, then water added to make a thick paste, and this thoroughly mixed again. This mortar is then spread out and the stone or gravel added, [when the whole is mixed together until every stone is thoroughly coated with mortar. When this is done the concrete may be put in place and should be spread out and pounded until the excessive moisture appears on the surface.

Masonry abutments should be of rock-faced ashlar, first-class in every respect. The projection of the rock face should not be more than three inches from the line of pitch. The stone used should be approved quarried stone laid on their natural beds, and all beds of stone dressed parallel and true, the bed to be always as large as the stones will admit. Vertical joints should be dressed not less than twelve inches in from the face, and as much more as the stone will admit, and particular care must be taken to have them well filled with mortar. Joints should in no cases exceed one-half of an inch in thickness. The courses ordinarily should not be less than eight inches in thickness. Each coarse should be dressed before laying, and not to be moved after being laid, or if moved, should be taken up cleaned and re-laid again in fresh mortar. The stones and work should be kept free from all dirt that will interfere with the adhesion of the mortar. Stones ought to be sprinkled with water before being placed in the work. Every stone must be laid with a full bed of mortar and beaten solid. Spaces in the vertical joints back from the face have to be built up, thoroughly grouted and each course finished off so as to be perfectly solid. Stretchers should be two and one-half feet in length, with a depth of one and one-half times their height.

Headers should be built in each course at least every four feet apart, and so arranged with the adjoining courses as to leave them equally distributed over the face of the structure. They should have a length in the face of the work of at least two feet and a depth of at least twice their length, unless the wall will not admit of this proportion, in which case, they will pass through from side to side of the wall. The backing or filling ought to be of good sized stones, and of such shape and so arranged that they will break joints and thoroughly bond the wall in all directions, and leave no space of more than six inches in diameter. All spaces must be filled in with small stones and spawls laid in mortar and thoroughly grouted.

The coping stones should be of the necessary sizes and shapes, well bedded and closely jointed. The upper surface should be bush hammered and the face

and corners brought to a true line. A tail wall, if built upon each abutment, may be of rubble stone work.

All mortar used in the masonry should be composed of clean, sharp sand, and an approved brand of cement. It should be of the best quality and freshly ground. The cement and sand for the mortar should be mixed in the proportion of three parts of sand by measure and one part of cement, the mortar to be made in a water-tight box or on a floor, and in no case on the ground. The ingredients should be mixed thoroughly in a dry state, and the proper amount of water added afterwards, and again thoroughly mixed. It must be used directly after mixing, or if not used within one hour after mixing should be discarded.

Design of Iron Bridges.

The design of iron or steel bridges commonly erected may be classified under: The plain beam or girder; the beam truss; the suspension truss; and the bowstring or arch truss. The first of these is well understood; the second comprises those trusses in which both bottom and top chords are essential; the third includes those in which the upper chord only is necessary; the fourth is not properly a truss, but an arch in which the horizontal tie takes the place of fixed abutments. The style chosen should be governed by circumstances and economy; but apart from this any design is good so long as it can be accurately analyzed as to the character and amount of strain in all its parts. On the other hand any design which cannot be so analyzed should not for a moment receive consideration.

The course pursued by some, indeed most municipalities, in erecting iron bridges is likely, however, to result disastrously, and throw iron and steel into disrepute. A council advertises for tenders. The companies responding supply their own plans and specifications. Thus far the procedure is entirely satisfactory. The difficulty arises when the councils accept the lowest tender without obtaining the advice of an experienced builder of iron bridges as to the plans and specifications submitted. Cases have occurred in which a difference of five dollars has influenced a council to accept a tender for a bridge which manifestly, to a man of experience, was worth less than the other by several hundred dollars; and which was indeed unsafe, offering every likelihood of failure with attendant loss of life and great expense for reconstruction. It is difficult to understand the action of councillors, shrewd in other matters, in the construction of bridges and other public works proceeding with such apparent disregard for the true interests of those whom they represent. A small sum in securing reliable advice is as much a matter of economy in public as in private affairs.

Painting Iron Bridges.

The prevention of rust is a matter of first importance in the care of iron and steel bridge work. The first principle in so doing is the exclusion of air and moisture. Galvanizing and painting are the two most commonly adopted means

for accomplishing this end. If the coating could in all cases be made continuous the result would be reached, but it is impossible to prevent slight breaks no larger than pin points perhaps, but which admit air and moisture. With these as a point of commencement, corrosion goes on beneath the coating, and is all the more dangerous because concealed. The durability of painted iron work depends largely upon the surface of the metal being properly cleaned and prepared to receive the paint or zinc coating. An ideal paint should have a toughness that does not depend upon a perishable ingredient; its elasticity should not be diminished by cold; it should not soften, but rather hardened by heat; and it should contain nothing which would act as a carrier of oxygen to the metal. Most engineers have a pet compound, that recommended by the chief engineer of the Bay of Quinte Railway being composed of one pound of lamp black, eight pounds of red lead, one gallon of raw linseed oil, the color being a rich chocolate brown.

Painting Wooden Bridges.

The painting of timber in bridges is a matter of some importance. The effect of paint on wet timber is to retain moisture and cause the so called "dry rot." If the timber is dry and well seasoned, the better practice is to apply a coating of paint at once. It is, however, a mistake to paint unseasoned timber in a bridge until it has stood a year; and the work should be done at the end of the summer when the wood is thoroughly dry.

Because of the tendency of paint to retain moisture, there has been some dispute as to the advisability of painting very large timbers in a bridge, the tendency of the paint being to increase the "dry rot." Nevertheless, the timber reaches a certain stage, after sufficient seasoning, when to exclude the atmosphere by painting tends to its preservation.

It is not considered good practice, however, in wooden bridge construction, to use any timber more than six inches in thickness. Where greater strength is required, in caps, beams, cords, braces, etc., a sufficient number of pieces of this or less thickness should be built together by keys, packing pieces and bolts, thus allowing a free circulation of air. Over members thus composed should be placed a covering of galvanized iron, extending a half or three quarters of an inch down on the timber, and secured by galvanized tacks, preventing the rain from entering the spaces or resting in or around the packed points.

The bridge thus built should be given one thorough coat of paint the summer following its construction, and a second one should be applied the third year. The ends of all timbers, all seats, joints and bearings should be well coated with white lead at the time of construction.

Economy of Iron Bridges.

The economy of iron and steel bridges for replacing wooden structures is a matter in which definite statistics are not available. The steel superstructure should last half a century, while the masonry piers and abutments, with first class

material and workmanship, and careful attention to repairs should be good for at least twice that period. The life of a wooden bridge may be placed at fifteen years ; and during that period expensive repairs will be required. If the cost of the iron and masonry bridge is twice that of the wooden structure there is still a wide margin for profit. The price of concrete, masonry and steel is constantly decreasing ; that of timber is becoming greater, while the quality available is degenerating ; and it is not difficult to fortell that, in future, culverts and bridges will necessarily be built of permanent and durable materials.

THE INFLUENCE OF PAVEMENTS ON PUBLIC HEALTH.*

In presenting to this association a paper on the sanitary aspect of pavements, I have been actuated by a desire to obtain information rather than to impart it. Ontario has so recently developed from a wilderness to the home of civilization and culture ; our villages have grown so quickly into towns, our towns into cities, and the advance of the various sciences has been so rapid, that our people scarcely realize the changed circumstances and the need of carefully directing their energies in meeting the demands of the times. In my visits to different parts of the Province I am constantly met with evidences of the good wrought by this association. I find that in very small villages even, inefficient drainage, cesspools, piggeries, slaughter houses, and impure water supplies are not now tolerated as they were once, and that this is due to the work of your association. It is with considerable hope, therefore, that I have undertaken to briefly lay before you the subject of pavements and public health, confident that you will lend your assistance in adding to our knowledge of this as of other matters pertaining to perfect sanitation ; and where reform is needed your aid will be afforded.

There is no one paving material which possesses every quality desired in a pavement to meet all conditions and uses. The ideal pavement remains to be discovered ; but the features which should belong to such an ideal pavement are so numerous and of such varying character as to render the search apparently a hopeless one. The ideal pavement : 1, should be cheap, and economical of maintenance ; 2, should be durable ; 3, should suit all classes of traffic ; 4, should offer little resistance to traction ; 5, should give a good foothold to horses ; 6, should be adapted to all grades ; 7, should have a good appearance ; 8, should not be muddy or pervious to water ; 9, should be sanitary, that is, non-absorbent, not subject to decay, easily cleaned, not dusty, not noisy.

It is apparent then that, notwithstanding the importance of the sanitary aspect of a pavement, there are other features which must be considered. The primary intention of a pavement is to accommodate travel, and to provide one which will do this satisfactorily, which will be durable, cheap, of good appearance, healthful, and possess in the highest degree the other qualities enumerated,

*A paper read before the Association of Medical Health Officers of Ontario.

in view of the location, nature and extent of traffic, is the problem which presents itself to the paving engineer. Just as no absolutely perfect paving for every time and place has been discovered, it is doubtful if any paving material now used should be utterly condemned. Each has its place in which, until the ideal, universal pavement is found it will be more satisfactory than any other which could be used under that particular set of circumstances of soil, climate, traffic, etc. The purpose of this paper, however, is to treat of the healthfulness of paving in general, of the sanitary aspect of commonly used paving materials, that is, asphalt, stone blocks, vitrified brick, cedar block, and broken stone, (macadam) with respect to absorption, decay, ease of cleaning, dustiness and noise.

Of all these, cedar block has received the greatest censure on the score of unhealthfulness. The late Dr. O. W. Wright, Health Officer of Detroit, is quoted as saying: "On sanitary grounds I must earnestly protest against the use of wooden block pavements. Such blocks, laid endwise, not only absorb water which dissolves out the albuminoid matter that acts as a putrefactive leaven, but also absorbs an infusion of horse manure and a great quantity of horse urine dropped on the street. The lower end of the blocks, resting on boards, clay or sand, soon becomes covered with a fungoid growth thoroughly saturated with albuminous extract and the excreta of animals in a liquid putrescible form. These wooden pavements undergo a decomposition in the warm season, and add to the unwholesomeness of the city. The street in fact, might as well be covered a foot deep with rotting barnyard manure so far as unwholesomeness is concerned. Moreover, the interstices between the blocks and the perforations of decay allow the foul liquids of the surface to flow through, supersaturating the earth beneath and constantly adding to the putrefying mass." Cedar block has been condemned in similar terms by many others. On the other hand, Col. Heywood, Engineer of the City of London, England, has said: "It has been said that wood pavements at all times smell offensively and may be unhealthy; but although some city streets have been paved with wood for thirty years, no complaints that I am aware of have been made to the commission on this head, and the inhabitants at all times have not only expressed great anxiety lest the wood should be replaced by other materials, but have subscribed towards the cost of its renewals. . . . I have at times noticed offensive emanations from it near cab-stands, but am unable to find further evidence of its unhealthfulness. These remarks must be held to apply only to public streets open to the sun and air, and traffic; in confined places and under some conditions, wood might be objectionable. I have seen it decaying in confined places without traffic."

The one statement by the Medical Health Officer of Detroit refers directly to the cedar block pavement as we understand it in this country. The other opinion, that of Col. Heywood of London, is expressed as regarding the wooden pavements as laid in European countries. Between these two pavements there is a vast difference. Under European practice, many of the pavements are of the

Karri and Jarrah woods of Australia, which are thoroughly saturated with resins, are very hard, and are not subject to decay. They are sawn into brick-like blocks and laid on concrete. Where soft woods are used, they are also cut into regular oblong blocks and laid on concrete, but are saturated with creosote or treated with some other preservative process.

Wooden pavements of America, however, represented by cedar blocks, are of a very different order. The round blocks of irregular diameter, are merely the untreated wood, still carrying the bark. These, placed on a bed of sand, are under the most favorable conditions possible for decay, being constantly exposed to moisture, air and warmth. With no preservative treatment they are enabled to absorb to the fullest extent all forms of liquid street-filth, which in the process of putrefaction, feeds on the organic matter of the wood. The surface, which quickly becomes uneven, retains a large quantity of loose matter subject to decay, the whole giving rise at times to noxious odors. The effect, were sufficient of such paving used, would subject us to the conditions favorable to marsh fever. From a sanitary standpoint, the cedar block pavement of this country would indicate a serious menace to health. At the same time, while we are justified as a matter of theory in arriving at this result, there do not appear to be any statistics to prove the conclusion to be a correct one. The death rate of cities most largely paved with cedar blocks does not bear any ratio to the extent of such pavement; nor does a change from cedar block to another less absorbent pavement produce a noticeable effect on the death rate.

In European practice, wood, more suited to a business street than macadam affording a better foot-hold for horses than asphalt, less noisy than granite setts, is exceeding popular in spite of its less sanitary character. In this country, however, there is an unwillingness to renew the wooden pavement when decay has rendered it unfit for further use, and this, coupled with the less careful method of laying, is the cause of the complete disrepute into which it has fallen.

Experiments have been made recently by a Polish scientist with regard to cedar blocks. The bacteriological examinations showed that, in specimens taken from blocks which had been in use for four years, and from a depth of one centimetre and two centimeters below the surface, there were at the end of five days 650,000, 220,000 and 12,100 bacteria per gramme of wood. A later examination showed 1,200,000 colonies per gramme in the surface of the wood, and 8,600 colonies at two centimes below the surface. An estimate, in terms of its nitrogen, was made of the organic matter absorbed by the wood, and indicated that the surface layer of wood contains more nitrogen than the most polluted soil. A comparative estimate of the pollution of the atmosphere was made by placing a definite quantity of sulphuric acid under a glass bell, on the surface of wooden and ashphalt pavements, the result, as indicated by the quantity of ammonia absorbed by the acid, being much in favor of asphalt.

The observations show that while a wooden pavement gives absolute protection to the soil and subsoil water, there was a considerable atmospheric contamination. The experiments were made on blocks of pine, preserved by impregnation with copper sulphate. Such being the case, with a wooden pavement laid under European practice, there can be little doubt of the unwholesome effect of cedar block upon the atmosphere. Further experiments of this description, conducted by members of your association, would doubtless prove instructive and profitable.

Broken stone or macadam would next arouse suspicion with regard to its absorptive qualities. There is this great difference between the two, however, that whereas a wooden pavement itself decays, and affords food for the decay of other organic matter falling on it, the macadam does not in itself decay. With under-drainage, such as a well-built macadam road, possesses it should be little more than a good sewage disposal bed for the comparatively small amount of sewage which falls upon it. A macadam pavement can be scraped, and swept, it is not too noisy, dust can be subdued by sprinkling, and on sanitary grounds appears to be an excellent pavement for residential streets where traffic is not excessive. For business streets, or for heavily travelled thoroughfares of cities, a harder surface is advisable. With regard to absorption, there can be no objection to asphalt, vitrified bricks, nor stone blocks. Asphalt is impervious to water; while the joints of brick or stone pavements are practically perfect so far as absorption is concerned.

A pavement, to be sanitary, should not be dusty. The dust of a pavement is not only an irritant, but carries with it the bacteria of disease, which from various sources are a part of street filth. To prevent dust, the pavement must be so perfectly cleaned that a practically harmless amount is taken up by the wind; or if perfect cleanliness is not possible, dust must be subdued by sprinkling. Unless perfectly cleaned, much better cleaned than is usually the case in this country, an asphalt pavement is apt to be a disagreeably dusty pavement on a windy day in summer.

This, indeed, is one of the greatest faults from a sanitary standpoint. Toronto has the reputation of being a clean city, with a well-organized street department; yet under these favorable conditions, a walk or drive down Yonge St. on a warm, windy day is a very trying experience. The smooth, hot surface quickly dries any matter falling upon it, a wheel passing over this dry substance grinds it to powder, and the result is that clouds of dust find their way into the eyes, nose, mouth, throat and lungs of pedestrians. Business men in their offices are not safe from attack, as it drifts in through the open windows. The dust imbeds itself in clothing, fastens itself on articles of food exposed in the shops, to be eaten finally by the purchaser. One case came to my notice in which a consumptive patient was ordered by his physician to leave Jarvis Street, one of the best resi-

dence streets of Toronto, because of the dust which came from the asphalted roadway. These streets are swept by machines, and are hand-swept by a corps of city employees, but are not, to my knowledge, flushed as are similar pavements in London and Paris. Flushing is the only method whereby asphalt can be freed from this unsanitary dustiness, but in addition to being expensive and hurtful to the asphalt, such a proposal will meet with the disapprobation of the engineer in charge of sewers. The dust, however, is not a defect of the pavement so much as it is a fault in the method of cleaning.

Asphalt has, nevertheless, the disadvantage of being a very hot pavement. Its smooth surface, reflecting back the heat and light, is productive at times of sun-stroke, and the glare is frequently painful to the eyes. This is most noticeable in closely built business sections where there is least circulation of air, where the sun beats down between high brick walls; and is not so objectionable on a shady residential street with houses well apart. Vitrified brick and stone block pavements are neither so dusty nor so hot as asphalt, since the surfaces are less smooth and assist in retaining in the joints the finer particles of dust. Sprinkling too, is in a greater measure effective in subduing dust on brick or stone block than on asphalt, from the hot, smooth surface of which moisture evaporates rapidly. A macadam pavement is dusty if not properly treated, but if scraped and swept as are other pavements, the dust can be largely subdued by sprinkling.

Noisiness, if excessive, is another unsanitary feature. A noisy pavement is jarring to the nerves, grating upon the sensibilities, and for either a heavily travelled business street, or a residential quarter, a quiet pavement is much to be desired. Noise itself is not always unhealthful. It is doubtful if the workman in a boiler factory, or a railroad engineer, or other employee, is much influenced by the noise incidental to his occupation. Both are muscular of body, constantly taking vigorous exercise. But to the more sedentary man of business, whether at high nervous tension in his office, or resting in the quiet of his home, a din, constant or intermittent, is a source of annoyance, and as such is wearing to the nervous system. The most objectionable in this regard is granite or other stone block pavement. Vitrified brick is apt, unless great precautions are taken, to create a disagreeable rumbling. Asphalt, wood and macadam are the least objectionable with respect to noise.

While we have this to say of the comparative healthfulness of different varieties of pavements, there is another condition of matters common to too many towns and cities, in which the streets, in fall and spring, form a wilderness of mud and stagnant pools, and in the summer are shapeless beds of dust. Many of them are made receptacles for the refuse from private property, which is left to disfigure the street, forming rivers of filth and cesspools of disease. Such streets have been regarded as a zero quantity, doing no particular harm, doing no particular good. Streets, however, which do no good, should do good, and therein

lies the harm. A good street is a well drained street, a well cleaned street, and is a source of healthfulness to the members of the community. Streets should be the public parks, pleasing to the cultivated taste, adding to the culture and refinement of the people, and enticing them to breathe health and vigor, whether walking, bicycling, riding or driving. Passing along the city street we reach the country highway, which as a means of permitting the people of the city to leave the congested portions and to reside in the less thickly populated suburbs, forms an important factor in securing public health

TOWN STREETS.

General descriptions of plans for street improvement have been issued in previous publications. Every town and city, however, possesses local circumstances peculiar to itself, requiring special consideration and adoption. The following report to the City Council of Windsor, Ontario, while containing, briefly, an outline of the means to be employed, and capable of universal application, contains references of a local nature, having much, nevertheless, of useful suggestion to other Councils:

To His Worship the Mayor and Members of the Council of the City of Windsor, Ontario.

GENTLEMEN.—In accordance with the request of your Council forwarded me by your city Clerk, I visited Windsor on the 2nd inst., examined the streets, and conferred with the Mayor, your Board of Works, Street Superintendent and City Clerk; and herewith submit the following report as to the present condition of the streets, the system of control, and the methods which should be adopted for their improvement:

Present Condition of Streets.

A number of streets, Sandwich, Pitt, Ouellette, Glengarry, Windsor, Church, London, Chatham, Dougall and others have been paved with cedar block. The majority of these pavements have survived their usefulness, and are now exceedingly rough from decay and wear. A few sections, such as Sandwich Street, from the G.T.R. bridge to Church Street, have been recently laid, and are still in serviceable condition.

The streets not paved with cedar block are dirt roadways which, during the summer, are kept nicely crowned, and the gutters well shaped and cleaned by the persistent and skillful use of a grading machine.

Broken stone has, in a few instances, been placed on top of these dirt roadways, but broken stone used in this way is of but little service in improving town streets; these are, by the general public, understood as "macadam" roads, but are totally devoid of the principles advocated by McAdam.

Expenditure.

The construction of cedar block pavement has cost \$172,331, during the past twelve years. On the repair of streets about \$10,000 is spent annually, which represents for the past twelve years, \$120,000.

The total amount then, spent by Windsor in the past twelve years, on pavements and sidewalks represents nearly \$300,000—over a quarter of a million dollars. This is a very large expenditure, one which, without better returns, no city of the size of Windsor can afford. The expenditure indicates on the part of the citizens, a most praiseworthy desire to advance the true interests of the city. It indicates that the importance of well-paved streets has been fully appreciated by the taxpayer; it indicates a willingness to pay for well-paved streets. It is in fairness to be pointed out that a considerable proportion of this has been spent on work from which permanent results could not be expected. There were annual repairs, street cleaning, removal of snow and similar details, from which only temporary benefit could be had. At the same time, it must be apparent to your council that permanent improvements are very few in comparison with the large expenditure. And notwithstanding its apparent simplicity, it is evident that the paving problem has not been solved in Windsor. Good streets cost a large amount of money, but bad streets cost vastly more.

Temporary Work.

While cedar block may at one time have been, in the opinion of some, a serviceable and economical pavement for business streets in the immediate business section, it was not an economical pavement on residential streets subjected to but little traffic, where failure must result from decay rather than from wear. For the residential streets of Windsor, much has been lost by overlooking the claims of broken stone roadways in place of cedar block. The mistakes which have arisen, and which by no means have been confined to Windsor alone, are the result of insufficient acquaintance with paving methods and materials, and a consequent misuse of them.

The dirt roadways which constantly require to be re-graded, which are good in the summer season only, and which in spring and fall become shapeless, muddy and of little use for travel, are a constant source of expense for repairs. In this case the error, in a sense, is the reverse of that arising from the use of cedar blocks on residential streets, the roadway being too weak to support the traffic, and the consequent outlay for repairs very great. Here again the use of macadam has been neglected. The expense of grading these streets year after year is very great. To obtain good results from the least expenditure, a larger amount should be spent in the first construction of permanent broken stone pavements, and a very much less amount in the repair of temporary dirt roads.

In sidewalks, no use has been made as yet of cement-concrete in place of plank, and the consequence is a large outlay for repairs.

Throughout the whole, there is an evidence of temporary construction which, cheapest in first cost, after a term of years when the cost of repairs is included, is the dearest. The waterworks system has been constructed at a cost of \$304,000. Since 1884 the sum of \$302,000 has been spent on sewers in addition to a considerable expenditure previous to that time for main sewers, the exact amount being difficult to ascertain, as it was raised in connection with funds for school purposes.

On the sewerage system, waterworks, public buildings, churches, places of business, and private residences, permanency has been sought. But in street work, sidewalks and pavements, it is apparent that a different policy has been pursued. Everything connected with streets has been built in the most temporary manner, little remaining to represent the expenditure but rotting blocks which will soon have to be removed; clay streets which dissolve after a shower; decaying sidewalks which are constantly being renewed.

Frontage Tax.

The Frontage Tax system has its advantages and, where the by-law has been carefully prepared, should give satisfaction. But very great care should be taken in framing the by-law so as to adjust it to local circumstances as far as possible. It is a simple means of raising the money, and of levying the tax, and when an equitable mode of assessment is provided, regulating corner, triangular, or irregularly-shaped lots, side-hill and similar property, as well as street intersections, levying a just proportion against the general funds, it invariably stimulates street improvement.

Unfortunately for Windsor, the system has not operated equitably in all cases. The residents of certain streets, with commendable loyalty to the best interests of the city have petitioned and paid for expensive pavements, in the expectation that other streets, equally able to bear the tax, would follow in due time. The result, however, has been that a number of important streets are still unpaved, and an undue amount of travel has been thrown on the improved streets; while the unimproved streets, by the use of the grader, and because of the little travel which they receive, are in as good condition.

The injustice does not appear to lie in the fact that streets other than those improved did not follow with improvements but that, unfortunately, the wrong materials were used, and the property-owners who made the improvement, are now called upon to repeat the expenditure. The fault does not lie in the frontage system but in the character of the work performed under it. Viewing it in this light, it may have been well for you citizens that no more work was undertaken with this class of material. Because in nearly every instance where cedar block was laid on residence streets, first-class macadam should have been used. Had this been done, with due attention and repair those streets would be in as good condition to-day as when first constructed.

Now that the subject is better understood, and councils and citizens are taking so much interest in the question, certain amendments to the Act would render the frontage system more just and workable, and these, no doubt, could be secured if proper representation were made. It would, for example, be better, in cases where the council considers it necessary to take the initiative, to require an adverse petition of two-thirds of the property owners; after which if the council still considers the work necessary they may proceed on a two-thirds vote of their own number.

Where the improvement of leading entrances to the city is undertaken and the property on either side of the street in the outlying sections is not built up or improved, or for any reason is unfit for building purposes, and the Council does not deem it equitable to assess such property in the same proportion as other property, then the Council should have the power, in all such cases, to determine the proportion.

And further, it would be well to provide by by-law for the payment of say one-third of the cost of all street improvements out of the general funds. When the Act was framed little interest was taken in the question of street improvement, and the intention undoubtedly was to permit the residents on certain streets, desiring their improvement, to have it made and the payments extended over a term of years; the principle being to allow them to get what they wanted and pay for it. This was taken advantage of by the more progressive citizens, but very seldom in a general way. With the changes of time and conditions, the demand to-day for improved streets is general, and no system should be adopted which will not to a reasonable extent provide for this.

An injustice to the outlying sections, less inclined to realize the advantages of improved streets, would be apparent at the first sight of this proposition, but

upon examination it will be seen that it would be found just and equitable. The opinion of the property holders in such sections generally is that streets demanding any improvement beyond the safe condition of the roadway, should pay for such improvement, believing that the benefits are purely local.

This, however, is erroneous, as no improvement can be made upon the streets of a city without benefitting the whole place. The nature, and consequently the cost of these improvements should be proportionate to the service which they render, and should not be wholly regulated according to the desire of the owners. Before any work is undertaken a comprehensive plan of the city outlining the character of the improvements proposed for the different streets, width of roadway, location of sidewalks, estimated cost, should be prepared, and followed as nearly as possible. The highest assessed property, where the most expensive pavement is required, pays a proportionately great share of the cost of that pavement as well as of the least expensive pavement.

Street intersections should be charged to the general funds, otherwise a street first undertaking improvement would be charged with all intersections, and other streets crossing this and subsequently undertaking improvements would be relieved from the cost of these street intersections.

In assessing the cost, the engineer should make an allowance on corner, triangular, or other irregularly shaped pieces of land situated at the intersection of streets. It is difficult to specify what this allowance should be, as regard must be taken to situation, superficial area, etc. A plan much favored is to charge two-thirds of the frontage on the side of the lot to be assessed.

The frontage tax system is a simple means of raising the money. No matter how small the work, the money can be easily provided. It is a check on careless management, because contracts must be separate, are not large, are understood by each property owner who feels directly interested, and studies the contract, watching closely its execution.

Whereas, under a plan of general assessment, money must be raised by by-law voted by the freeholders generally; consequently in large sums which would not likely be expended as judiciously or the work performed as economically. Where an effort is made to raise as large a sum of money as would be required to perform even the most important work, considerable opposition would be offered by sections not directly benefitted, and subsequent by-laws would meet much opposition from those previously served. The frequent submission of by-laws for any purpose is found objectionable.

Some expression was given to the wisdom of returning to a system of general taxation for street improvements. Under this system the main streets and entrances to the city might be more quickly paved; nevertheless it would form a total denial of the principle embodied in the frontage tax system, that the property directly benefitted should bear the greater proportion of the cost; and at the same time, as pointed out, there are difficulties to be encountered in passing the necessary by-laws raising large amounts of money, created by sectional jealousies and other causes which cannot definitely be foreseen.

The Ward System.

Good streets and the ward system are incompatible. Under any circumstances, the ward system of representation is not favorable to the best city government, and with a system of general taxation for street improvement, its abolition (for which recent legislation provides) becomes imperative. Every year, in

the larger municipalities, several thousands of dollars are divided among the wards; and this again is subdivided by the representative, or under his influence, and is scattered over the street area. Frequently work is attempted which is never completed, and not infrequently, work is done which would be better undone. It is in direct violation of the more economic management of streets whereby the expenditure would be concentrated in work of a substantial and finished character, and afterwards systematically maintained. Instead of this, under the ward system the effort is to build streets by an extensive series of disconnected patches, and to repair streets which were never constructed.

A Standard Pavement.

A standard pavement in Windsor for streets other than those in the immediate business section should be macadam. A well-kept macadam driveway is in keeping with well-kept boulevards, lawns and shade trees, the characteristics of a residential street; it has a cool appearance, the dust can readily be kept down by sprinkling, and for light driving is the favorite among horsemen. Bicyclists, now an important section of the community, usually favor macadam, in preference to the more costly classes of pavement. A comparison of macadam with asphalt or vitrified brick, in point of utility and beauty, will not result unfavorably to the former, for use on residential streets. It is not to be inferred, however, that broken stone roadways are recommended for streets in the immediate business section, where a harder and, in a sense, a cleaner surface is desirable.

By proper attention to repairs, the life of this class of pavement can be made continuous. The surface can be frequently rolled, improving it greatly. It can be scraped and swept as are other pavements. When it begins to lose shape the surface can be loosened up by means of teeth attached to the roller, a light coating of new metal applied, and then rolled down as well as when new. It is by such means as these that broken stone roadways can be made much more economical and satisfactory than any other for streets generally. This ease of renewal, and repair is a property peculiar to macadam, which renders it most satisfactory for general purposes. While the cost in the first instance may nearly equal that of cedar block, yet at the termination of the period when cedar block is decayed and has to be torn up or renewed, the macadam, if properly treated, is still in a good condition. It forms a permanent basis, and its perpetuation is merely a matter of repair to be met by the general funds.

Except under excessive wear, or where in business sections a high-grade pavement is necessary, broken stone pavements, by the aid of a steam road roller, are beyond doubt the most serviceable and economical, and give greatest satisfaction to the taxpayer.

Cedar Block..

The real life of cedar block paving will average only about seven years. Up to that time the surface is moderately smooth. Many of these pavements are allowed to stand, however, for ten or twelve years, at the end of which time they have become almost impassable, for the last half of their existence having received constant repairs, the cost of which is very great, a fact which your council must be experiencing in the effort to keep your cedar pavement in repair. Except for a few years after construction, cedar block makes a very rough road surface, is temporary, dirty, unsanitary, and the appearance is unsatisfactory. This is the result of Canadian experience with cedar block, except under favorable conditions which do not exist in Windsor.

Asphalt and Brick.

For a pavement such as is required in the business sections of your city, the essential qualities are :

- (1) A secure and pleasant footing for horses.
- (2) Smooth, so as to render travelling and traction agreeable, easy and noiseless.
- (3) It should be sanitary ; the form and material such that it will be imperious, liquids will not have permanent lodgement, and dust will not be easily produced.
- (4) The durability and service rendered will be commensurate with the cost of construction and maintenance ; that is, it must be economical.
- (5) It must be easy of removal, replacement and repair at reasonable cost, and with the appliances and materials within the control of the corporation.

In view of the above it will be apparent, I believe, that brick and asphalt are the two competing materials. With regard to the first quality, the foothold afforded to horses, brick must have the preference. It is one of the objectionable features of asphalt that it is exceedingly slippery when wet, and even when dry it is not always safe.

As to the second quality, asphalt must take first place since it is in a slight degree smoother and less noisy than brick. It is doubtful, however, if traction is any easier, owing to the insecure footing afforded to horses.

There is little if any difference between the sanitary status of the two pavements. Both are, of course, impermeable and offer little resistance to the flow of liquids ; the joints of the brick are just sufficient to retain moisture and subdue dust. With the smooth asphalt surface no amount of sprinkling will keep the surface moist in hot weather.

As to cost, asphalt is from one-half to one-third more than brick, and experience has not proven its life to be any greater. As to durability, there must always be the proviso that good material and proper plans and methods of construction are used in any case.

The laying or repairing of brick does not require skilled labor as does asphalt, and this difficulty in connection with the latter is felt more particularly in places where only a short section of asphalt is used. In large cities the inconvenience is not so great.

While asphalt is extensively used in the United States and Canada, and is unquestionably a good paving material for certain streets of large cities, I believe brick to be more suited to the requirements of your City.

The quality of a brick pavement is not to be gauged by the best brick used in its construction, but by the poorest. For this reason it is necessary, in deciding on the kind to use, to see that it comes up to the standard of scientific tests. More than this, while the building of the pavement is in progress there should be careful inspection to see that no brick of an inferior quality is used.

There is a tendency also, to reduce the cost of a pavement by having a cheap foundation. Foundations of gravel, sand and macadam have proven successful in a number of cases, but only were the natural sub-soil is of a loose and porous nature. In this climate where we are subjected to alternatives of frost and slush, the experiment is a dangerous one. A foundation of six inches of concrete should be used. On this, place a one-inch cushion of sand, and fill the joints of the brick with a cement of tar and sand. The earth sub-soil should, of course, have been previously graded and thoroughly consolidated with a heavy roller.

Cost of Pavements.

A suitable asphalt pavement on a six inch concrete foundation, with a five year guarantee, in Windsor would cost \$2.50 per square yard ; with maintenance guarantee for fifteen years, the cost would be about \$3.00 per square yard. A vitrified brick pavement laid on a similar foundation would cost approximately, \$1.75 per square yard and should last for fifteen years. A first-class macadam pavement would cost about 75 cents per square yard, the life of which would be continuous by means of proper repair. On a 24-foot roadway where the curbing is now set, the cost to an average lot having fifty feet of frontage, for such a macadam road would be \$4.21 per annum for ten years, providing that street intersections and one-third of the cost were charged to the general funds.

Classification of Streets.

To place any system on a satisfactory and equitable basis, the improvements must be made in a business-like manner according to a carefully prepared plan which will adjust the right class of pavement to each of the streets, according to traffic and requirements.

In preparing such a plan the streets must be classified. It may emphasize the effect of classification by pointing out that a light macadam roadway costing 25 cents per square yard for a little travelled street, and an asphalt pavement, costing \$2.50 per square yard for a business block, would each be economical and satisfactory, yet they could not be interchanged except at a loss. A light macadam on a business street is quite as unwise an investment as asphalt would be on one of the least important streets. The main streets in the business sections, naturally fall into a class by themselves, requiring the most expensive form of pavement. These in Windsor, are Sandwich Street from the C.P.R. Bridge to Church Street ; Ouellette Street from Sandwich Street to London Street; Pitt Street from Windsor Avenue to Ferry Street ; and Goyeau Street, from Pitt to Sandwich Street. On these sections, as has been pointed out, vitrified brick is the most suitable pavement (except, for the present, that portion of Sandwich Street from the C.P.R. bridge to Church Street, which has recently been paved with cedar block).

There are other streets heavily travelled, but which do not require so expensive a form of pavement as those just enumerated, and for which a strong macadam is most suitable. Such streets are : Sandwich Street from the C.P.R. bridge westerly ; Sandwich Street from Glengarry Avenue to Walkerville ; Wyandotte Street ; Howard Avenue the main entrance to the City from the south ; Glengarry Avenue, Aylmer, and London Streets the main entrance to the City from the west.

A lighter form of macadam may be used on a third class, comprising such residential streets as Goyeau Street, Ouellette Avenue, Dougall Avenue, Chatham, Church and Pellissier Streets (the last mentioned newly block-paved).

On streets of less importance a still lighter macadam may be used ; constructed however, in all respects according to the best principles of road-making.

In laying down a system of waterworks, the first step to be taken is to prepare a plan of the whole municipality and determine the size of the pipes to be laid on each street to meet the requirements. The sizes of pipes are classified, main, circuit and lateral, and range possibly in size from a 24-inch main to a 4-inch lateral. The 4-inch pipe is as efficient as the 24-inch, considering the service it has to perform. Interchanged they would be useless. Much economy is practised in the careful designing of such a plant. So also should it be with

sewers, and before any work is undertaken, a plan should be prepared, not only providing for present, but as far as may be, for future requirements in capacity and disposal. As with waterworks and sewers so it is with streets. Before anything is done a similar plan should be prepared which will adjust the right class of pavement to each street according to requirements.

Construction of Broken Stone Roadways.

Macadam or broken stone roadways have not yet been understood in your city. The practice has been to pile broken stone in the centre of the roadway on top of the natural soil, or to bring the earth from the gutters to the centre of the roadway, placing the stone on top of this. This is the plan usually followed in grading township roads, but is unsuited to city street construction.

The roadbed should be excavated to the required width to receive the broken stone, and the excavated earth may be used in making boulevards or filling in the low lots to bring them to the grade of the street. The side of the street should be levelled to conform to the surface of the roadway. The general plan is much the same as for cedar blocks, except that a broken stone roadbed is used instead of cedar blocks. From 24 to 26 feet between curbs is a sufficient width of pavement, except where the street railway is laid, when extra provision should be made, for a single or double track, as the case may be.

The stone should be broken by means of a rock crushing machine which should be owned and operated by the city. In order to lessen the initial cost, small crushers are often purchased with the intention of operating them to their full capacity. Owing to the great variation in material, and the severe trials to which these machines are subjected, it is advisable to provide a machine which will not have to be operated to its full capacity. One of about two cords per hour of which only two-thirds the capacity should be used, would be suitable. The extra cost would prove a profitable investment.

By having a rotary screen attached to the crusher, the stone as it passes through is graded according to size. The grading of the metal is the most important part of the work which the crusher has to perform. When stone is placed on a road without being graded, large stones surrounded by smaller, the latter wear more quickly, and the surface becomes uneven. The large stones also, do not rest firmly on the surface, but are more easily disturbed and are apt to roll loosely under the wheels of vehicles and the feet of horses. Material of uniform size, placed in regular layers of coarseness, properly consolidated, will form a smooth surface, distributing traffic and wear uniformly. The grades of stone frequently are :

- 1st. Such as will pass through a $2\frac{1}{2}$ inch ring.
- 2nd. Such as will pass through a $1\frac{1}{2}$ inch ring.
- 3rd. Such as will pass through a 1 inch ring.
- 4th. Chips and dust screenings.

The stone should be placed on the roadbed in layers of not more than four inches in thickness, the total thickness of the covering to range from eight to twelve inches according to the strength of road required to support the travel. With each layer should be mixed a quantity of the chips and stone dust to assist in consolidation; and the surface should be finished off with a thin coating of screenings.

More stone should be placed at the centre, than at the sides. Where the thickness in the center is twelve inches, that at the curb should be about eight

inches. The thickness of the different courses from the bottom upwards, would be eight inches of two and one-half inch stone; three inches of one and one-half inch stone; and one inch of inch stone. At the curb, the thickness of each layer will be proportionately less.

In the process of laying, the material should be thoroughly rolled, and consolidation assisted by a liberal application of water. Excellent samples of this class of road may be conveniently seen by your Council in London, St. Thomas, Ingersoll, Stratford, Galt and numerous other points.

After the excavation and boulevarding has been completed, the curbing set, the foundation underdrained and sub-grade thoroughly rolled, an excellent plan, where the material can be procured, is to place a layer of quarry flake stone, from two to four inches in thickness, in the bottom of the roadway, and then to place on top of this about nine inches of hard, crushed stone coursed and in layers as previously specified. Quarry stone for the foundation, or for the first layers of the roadway, could be obtained from Amherstburg at a cost of \$3.00 per cord f. o. b. Amherstburg. The material can also be obtained in large quantities at Pelee Island. Field stone for finishing the road can be obtained in the vicinity of Kingsville, Harrow and Ruthven, and costs f. o. b. at those places about \$2.75 per cord—to which must be added the cost of freight and crushing. In all this would amount to about \$6.50 per cord crushed at Windsor.

Of course the harder and tougher the stone used for surfacing the street, the more durable will be the roadway. Trap rock is undoubtedly the best material. Its scarcity, however, limits its use. It can be had in large quantities from the north shore of Lake Superior, the city of Cleveland importing largely from that district by boat. Being located on the route, you should be in a position to obtain this material at reasonable cost.

Rolling.

For economical, durable and serviceable roadmaking, a heavy roller is indispensable. A road should be sufficiently smooth and compact to shed the water readily to the side gutters. If the gravel or other metal is dropped from the wagon loosely on a soft earth foundation, as is your practice, water passes into the sub-soil as ~~into~~ a sieve. Wheels passing over the road when in such a condition at once sink into and rut not only the gravel, but the earth beneath. Water is held in the ruts and each succeeding vehicle renders their condition worse. The road is less durable since, the gravel being mixed with the dirt beneath, it obtains, when fully consolidated, a dusty, easily-worn surface.

The weight of roller must depend upon various circumstances—the amount of work it will be required to do, the quantity of road metal used, the strength of the bridges and culverts over which it must pass. A steam roller costs more than a horse roller, but does so much better and faster work that it is more economical. A nominal $12\frac{1}{2}$ ton steam roller is commonly used, and would be most suitable for your city.

Curbing.

The streets which are block paved have been provided with stone curbing which is a very important detail of a well-designed street. It is the one part of the work in Windsor which, in first construction, was made of durable material and does not need to be renewed. This curbing defines the roadway, protects the boulevards and gutters and keeps the paving material in place; and on all other streets the same plan should be continued.

Drainage.

From the lay of the land, the quality of the soil and the climate, the necessity of perfect drainage is possibly greater in Windsor than in any other city of Ontario. The land is flat, the soil retentive of moisture, and the changes of freezing and thawing are frequent. Without properly draining the foundation it would be useless to attempt to construct and maintain good macadam or other pavement, but with a thorough system of drainage no better foundation could be desired.

Underdrainage is one of the first points to consider. In making streets it is the native soil which must really support the weight of the traffic, no matter what paving material is used to surface it. Gravel, stone, brick or asphalt are not sufficiently strong to bridge over a wet and yielding subsoil. But if this natural soil is kept in a dry state it can support any weight, and to this end underdrainage is necessary. Underdrainage of common field tile, four to six inches in diameter, should be placed on each side of the carriageway underneath the gutters, and below frost. This "lowers the water line" and secures a good foundation.

There must be surface drainage, and for this the roadway should be crowned or rounded up, covered with suitable surface material, and open gutters provided to carry away the surface water. The surface metal, of course, resists wear, but on streets which are lightly travelled the main object is to provide a cover which will prevent the water penetrating the natural soil underneath, making it unfit to support traffic. By crowning the surface of the road, water is shed at once to the side, where provision should be made to carry it away immediately in open gutters.

The amount of crown varies with the width of the roadway and character of the surfacing. For a macadam roadway, the crown ranges from one inch to one-half an inch per foot from the curb to the center of the road, the crown decreasing as the width of roadway increases.

Gutters or underdrains are useless unless outlets are provided, and care should be taken to see that these do not become obstructed. Surface drains and underdrains should have outlets into catch-basins, leading into the sewers, if capacity for storm water is provided.

Springs underneath roadways should be tapped with blind drains and the water carried diagonally to the underdrains at the side of the streets.

Main Entrances to the City.

There are portions of main entrances to the city, such as Sandwich street West, Howard avenue, Glengarry avenue and London street West, in the outlying sections of the city, where it is not advisable to pave the full width of the roadway, nor to curb it. With the foundation underdrained, and gutters made to carry away the surface water, the roadway should then be graded, leaving an excavation in the central portion a width of twelve feet and a depth of twelve inches, to receive the road metal. In this excavation should first be placed a layer about four inches thick of quarry flake stones laid closely together. On this should be placed eight inches of stone broken and coursed according to size as before specified, and thoroughly rolled. The underdrainage should be obtained by placing a row of common field tile on each side of the roadway underneath the open gutters; and diagonal drains across the roadbed at wet points. From four to six-inch tile is usually sufficient.

Sidewalks.

Sidewalks will be required in Windsor as long as the city exists and their construction in the most permanent manner possible is a part of the same principle that directs the erection of the places of business of a durable material. Planks used in sidewalks are subjected to an exceedingly severe test. They are lying close to the ground, always absorbing moisture on the underside, and are exposed to repeated changes of wet and dry. The average life of plank in this work is not more than five years until decay commences and repairs are demanded. These repairs increase annually, and walks may be and are carried for ten or twelve years, by which time the cost of repairs has almost equalled that of renewal. Every city in Ontario has laid and is laying large quantities of granolithic (cement-concrete), while nearly all towns and in fact many villages have made use of this more durable material.

In cement-concrete, sand finish, the surface coat is composed of sand and cement; while with cement-concrete granite finish (granolithic), granite, cement and sand are used. The sand finish is useful on residential streets, or other streets subjected to moderate traffic; while the granolithic forms a harder wearing surface for much-travelled streets.

The life of this class of walk is indefinite. The first walks of this material in Toronto were laid in one of the most heavily travelled sections about thirteen years ago, and are to all appearance as good as when new. Other cities have used sidewalks of cement-concrete for twenty years, which are still in excellent condition. There appears to be no reason why perfectly built walks of this material should not last half a century.

Artificial stone (cement-concrete) makes a durable, economical and satisfactory walk and this material should replace plank as rapidly as possible in your city. Of course, as with any work, care must be exercised to select the best material, and provide the best workmanship. A point frequently overlooked in concrete sidewalk construction is the necessity for perfect drainage, a matter of importance in all paving work in this country where the action of frost is so severe. Should your council desire it, I will furnish a standard specification for the construction of these walks.

Recommendations.

Summarizing the preceeding discussion, the main recommendations which I would lay before your council are as follows:—

1. That a plan of the city be prepared, classifying the streets according to traffic and requirements, adjusting the right class of pavement to each street, fixing grades, width of roadway, boulevards and location of sidewalks.
2. That the frontage tax system for street improvement be retained but so amended as to require the adverse petition of two-thirds of the property owners to annul the initiative of the council; after which the further power is given the council to perform the work on a two-thirds vote of the council. The system should be amended also so as to assess one-third the cost of all work against the general funds of the city if favorable legislation can be obtained.
3. That the ward system be abolished.
4. That less be expended in the temporary grading of dirt roadways, and more diverted to permanent work each year.
5. That broken stone roadways be laid on residential streets, the general plan to be as specified herein.

6. That vitrified brick be used on business streets in the immediate business sections.
7. That a nominal $12\frac{1}{2}$ -ton steam roller, and a rock crusher of at least two cords per hour capacity, be purchased.
8. That plank sidewalks be replaced with cement-concrete as rapidly as possible—granolithic finish in business sections, sand finish on residential streets.

SPECIFICATIONS FOR CEMENT-CONCRETE WALKS.

The following form of specification includes the most necessary requirements for laying artificial stone walks by contract. They should, however, be varied as circumstances may render expedient:—

1. The location and approximate extent of artificial stone side walks to be laid under these specifications are as follows : Location and extent of walks.
2. The corporation shall remove the old plank, stone, brick, and other sidewalk from the street before the construction of the new walk shall be commenced by the contractor, all such material being the property of the town, to be disposed of as the engineer may direct. Removal of old sidewalks.
3. All excavated earth, stones, posts, stumps, other obstacles or rubbish shall remain the property of the town, to be removed by the contractor to such point or points as the engineer may direct ; if not hauled for a distance exceeding one half mile, such removal to be without extra charge. Removal of earth and rubbish.
4. The walk shall be laid to the lines and levels given by the engineer. No Levels, stakes or bench-marks placed for this purpose by the engineer shall be moved or effaced by the contractor without the permission of the engineer so to do. stakes and bench-marks.
5. The space over which the walk is to be laid shall be excavated to a depth of twelve inches below the elevation of the finished walk in accordance with the plans and profiles, on file at the office of the engineer. Perishable or objectional material shall be removed to a further depth, to secure a firm foundation if so required by the engineer. Such excavation in excess of twelve inches shall be filled with gravel, or other material approved by the engineer, and the bottom of the sub-grade thus obtained shall be then made thoroughly firm and solid by pounding or rolling. For all excavation or filling ordered by the engineer in excess of twelve inches below the grade of the finished walk, the contractor shall be entitled to the sum of 35 cents per cubic yard. Preliminary excavation and earth-work.
6. A porous tile drain shall be laid centrally beneath the walk, to the depth, grade, of such diameter, and carried to such outlets as are specified upon the plan and profile on file at the office of the engineer ; and tile drains for carrying surface and other water through or under the walk shall be laid as indicated upon the aforesaid plan and profile. All tile used shall be of the best quality of clay, manufactured expressly for drainage purposes, in lengths not less than one foot, and of uniform diameter throughout. All earth excavated in the laying of these drains shall be returned to the trench, being thoroughly rammed and pounded in layers not exceeding one foot in thickness, and rendered perfectly firm and solid, to the satisfaction of the engineer. When sewer pipe is required in place of common tile, such pipe shall be furnished to the contractor by the engineer ; and shall be laid in all respects to the satisfaction of the engineer. Tile drainage.
7. Upon the sub-grade thus excavated, drained and consolidated, shall be spread a layer of clean gravel or broken stone to be thoroughly wetted, rolled or pounded, and brought to an even surface. The layer of gravel or stone so placed shall have a thickness of seven inches ; and shall be uniformly not less than five inches below the elevation of the surface of the finished walk, having preference A layer of gravel or broken stone seven inches in thickness.

A layer of concrete, four inches in thickness.

8. Upon the foundation thus prepared, a layer of concrete shall be laid in the following manner : It shall be composed of one part by measure of fresh cement, of a quality approved by the engineer, and in accordance with the specifications for such elsewhere herein described ; three parts by measure of clean, sharp sand ; and five parts by measure of broken stone of such a size as will pass through a two-inch ring. The concrete shall be mixed in a water-tight box placed close to the work, by first spreading evenly a layer of sand ; upon this shall be evenly spread the proportionate quantity of cement and the two thoroughly mixed while dry. To this water shall be added and the whole thoroughly mixed and brought to the consistency of mortar. The proportionate amount of stone shall then be spread evenly over this mortar and thoroughly intermixed therewith. The concrete when mixed as aforesaid, shall be immediately put in place and thoroughly pounded until it has an even surface, is perfectly and uniformly solid, and is four inches in depth over the foundation and within one inch of the finished surface of the walk. Slab or flag divisions shall then be marked off, sixteen feet in area, the joints to be filled with clean sand or other approved separating material.

A layer of concrete one inch in thickness.

9. Before the aforesaid layer of concrete has set, and while it is still adhesive, there shall be laid upon it a wearing surface one inch in thickness. It shall be composed of one part by measure of Portland cement, and two parts by measure of clean sharp sand. The cement and sand shall be mixed dry, water then added to moisten sufficiently, the whole again thoroughly manipulated and mixed in a water-tight box or floor and immediately put in place. The layer shall then be thoroughly pounded, and worked to a true and even surface. Over this shall be sifted a layer of Portland cement, the whole to be neatly levelled to a perfectly smooth surface, and rolled with a tooth roller to make a surface that will not be slippery. This surface layer shall be cut into sections, the joints to correspond exactly with those of the first described layer of concrete, the edges of the walk to be rounded, and the whole finished in a neat and workmanlike manner.

Temporary curbs to be supplied by contractor.

10. Before any concrete is placed in the walk, temporary curbs, of 2 x 6 pine, with edges dressed so as to be perfectly straight, shall be firmly and accurately placed along the outer edges of the walk, to be removed after the walk has hardened ; these curbs to be furnished by, and remain the property of the contractor. When the curb is removed, the vacant space must be filled with good soil, and any sodding disturbed in so doing must be carefully restored.

Total thickness and slope of walk.

11. The total thickness of the walk, including foundation layer, concrete layer, and the wearing surface, shall be uniform throughout, and shall have a slope towards the roadway of $\frac{1}{4}$ -inch to the foot, unless otherwise required by the engineer.

Cement.

12. All cement used in the work must be of some well and favorably known brand, and shall be approved by the engineer. It shall be delivered in barrels or equally tight receptacles, and must be protected from the weather by storing in a tight building or by suitable covering, the packages to be placed on boards or flooring raised above the ground. All cement rejected by the engineer shall be conspicuously marked "Condemned," and shall be immediately removed from the site of the work. Should any cement so rejected be thereafter used in the walk, such sections as may be required by the engineer, shall be immediately torn up by the contractor, and replaced with cement of proper quality, without extra compensation. The supply of cement must be so gauged that a sufficient quantity will be kept on hand to allow ample time for testing and examination by the engineer, without delay to the work of construction ; the cement to conform to the following tests, and such others as the engineer may require :—

(a) At least 90 per cent. shall pass through a sieve having 10,000 holes to the square inch.

(b) Pats made of neat cement, with thin edges, on pieces of glass, covered with a damp cloth, and allowed to set in air ; then placed in boiling water 48 hours, must not show expansion cracks, distortion, nor curling of the thin edges.

(c) Samples of cement shall be made into the consistency of a stiff mortar, pressed firmly into moulds, and covered with a damp cloth, then allowed to set in air 24 hours, then in water three, and seven days. When in water three days, six samples shall show an average tensile strength of 300 pounds per square inch ; when in water seven days, six samples shall show an average tensile strength of 450 pounds per square inch.

13. The stone and sand shall at all times be subject to the approval of the Sand and engineer, the sand to be clean, sharp and silicious. stone.

14. At street crossings, lanes and private driveways, the walk shall be so rounded, placed, and at such an elevation as to give a convenient passage for vehicles, to the satisfaction of the engineer. The surface layer of concrete shall be $1\frac{1}{4}$ inches thick, composed of equal parts by measure of cement and sand, and marked into diamond shaped blocks by lines crossing the walk diagonally six inches apart. The edges shall be rounded, and faced to the bottom of the concrete with the cement mortar used for surfacing the walk. At all street crossings, and elsewhere if so desired by the engineer, the edges of the walk shall be protected by a curbing of 4 x 6 cedar, placed in a permanent and durable manner, flush with the surface of the walk.

15. The contractor, in doing the work, shall excavate or fill in around trees in a careful manner so as not to injure the said trees; and all gratings, areas, tree-spaces, or other interruptions to the walk shall be regarded as continuous in the payment of the walk. The repairing or building up of area walls or other supports for gratings shall be performed and the material supplied by the contractor, as the engineer shall direct.

16. No concrete shall be laid in wet or freezing weather.

Laying concrete in wet or freezing weather.

17. Care must at all times be taken to prevent injury to waterworks stopcock-boxes, down pipes, door sills, steps, areas, gratings, or other appliances which may be under, project into, or pass through the walk, and the pavement shall be carefully and neatly filled around such appliances. When required by the engineer, all gratings or covers furnished the contractor shall be properly fitted into and conform to the surface of the walk.

Prevention of injury to waterworks and other appliances.

18. The contractor shall be bound to maintain the walks and crossings in perfect repair, free from all cracks and defects, for the term of five years from the date of completion thereof, and should the contractor fail to do so at any time during the said term, the engineer may cause the necessary repairs to be made, retaining the cost from moneys due, or becoming due to the said contractor on this or any other contract between the town and the contractor, or may recover the same from the contractor, or his sureties in this contract, as money paid at their request. The certificate of the engineer is to be final as to the necessity of repairs and amount expended upon them.

Contractor to maintain walk in perfect repair for five years from date of completion.

19. Care shall be taken at all times not to interfere with business or travel more than is absolutely necessary for the faithful performance of the work. The contractor shall make suitable and adequate provision for the safe and free passage of persons by or over the work, as may in the opinion of the engineer be necessary, and must confine himself to that half of the street on which the sidewalk is being put down, leaving the other half for the regular traffic.

Interference with traffic.

20. At all times during the progress of the work care must be taken not to unnecessarily injure or destroy private lawns, nor boulevards adjacent to the walk. On the completion of the work all surplus or refuse material must be immediately removed from the street by the contractor. If not removed within forty-eight hours after notice in writing so to do from the engineer, it shall be removed by the engineer at the contractor's expense.

Care of private lawns, boulevards, and removal of surplus material.

21. The contractor shall, during the progress of the work, use all proper precautions by good and sufficient barriers, red lights, or watchmen, for the prevention of accident, and he will indemnify and save the corporation of the town of from all suits and actions, and all costs and damages occasioned by the negligence or carelessness of the contractor or his agents, or employees.

Liability in case of accident.

22. The contractor or his duly authorized agent or foreman shall at all times while work is in progress, be on the ground, and instruction given by the engineer to such agent or foreman shall be of the same effect as if given to the contractor.

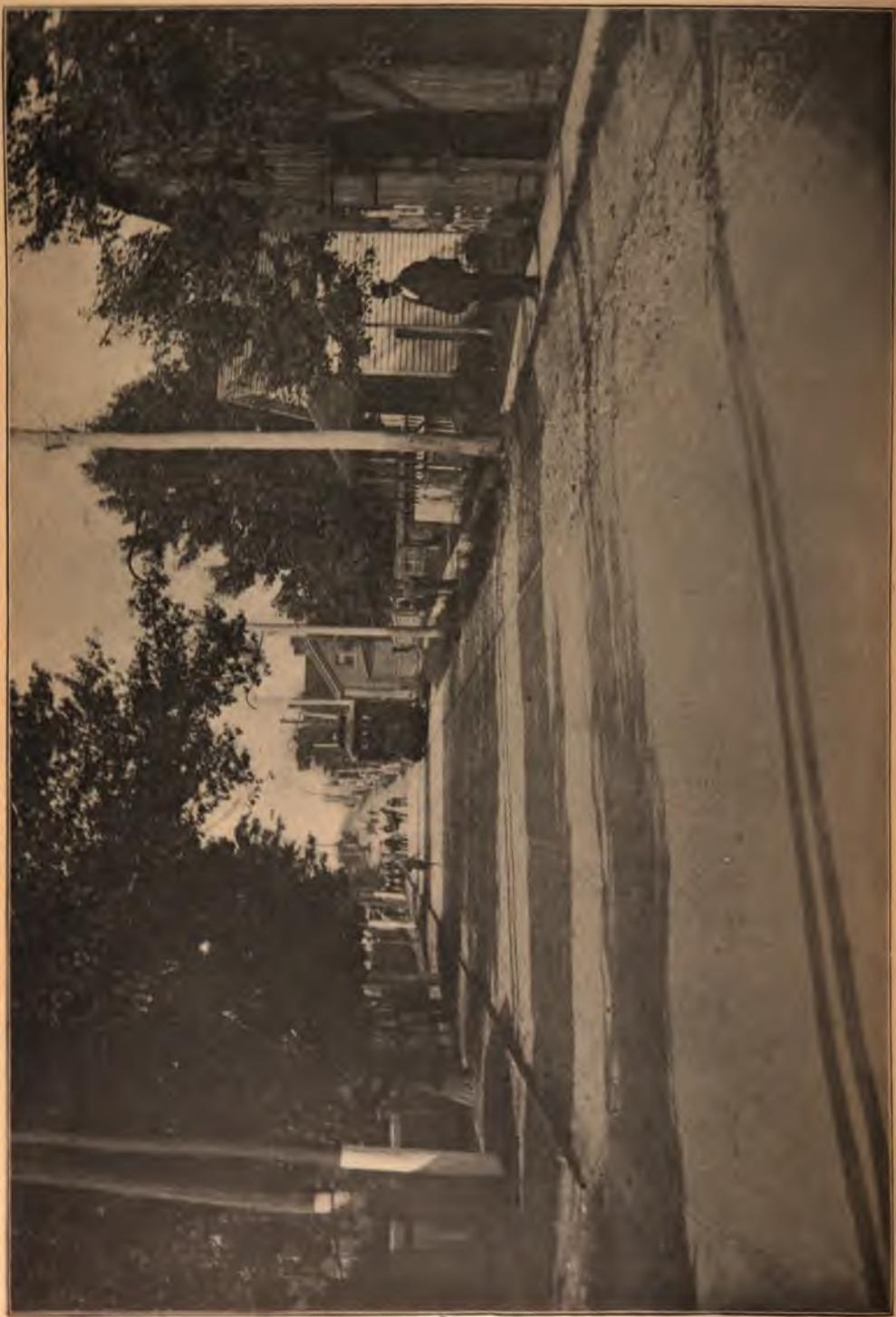
Contractor or his agent to be on the work while in progress.

23. The word engineer, where and whenever used herein, refers to the engineer of the town of or his authorized assistants, or other person appointed by the council of the town of to have charge and oversight of the defined work.

Engineer defined.

24. The decision of the engineer shall be final in case of ambiguity of expression in the specifications, or doubt as to the correct interpretation thereof.

Interpretation of specification.



IN MERITON
Street macadamized in 1898.



IN MERRITON.
Street macadamized in 1898.



DRAIN THE ROADS!



DRAIN THE ROADS!



DRAIN THE ROADS!

A knowledge of how to drain the roads most perfectly is the basis of successful roadmaking.



ARCH CULVERT OF CONCRETE.



ARCH CULVERT OF CONCRETE.

THE LAKE SHORE ROAD.

One of the oldest roads in Ontario, once an Indian trail, but now improved (?) by statute labor.





IMPROVED ROADS LEAD TO IMPROVED FARMS.



WELL NAMED.
“Canal Street,” Ottawa.

